Mecheleciv

VOL. 16 MAY 1957 NO. 6

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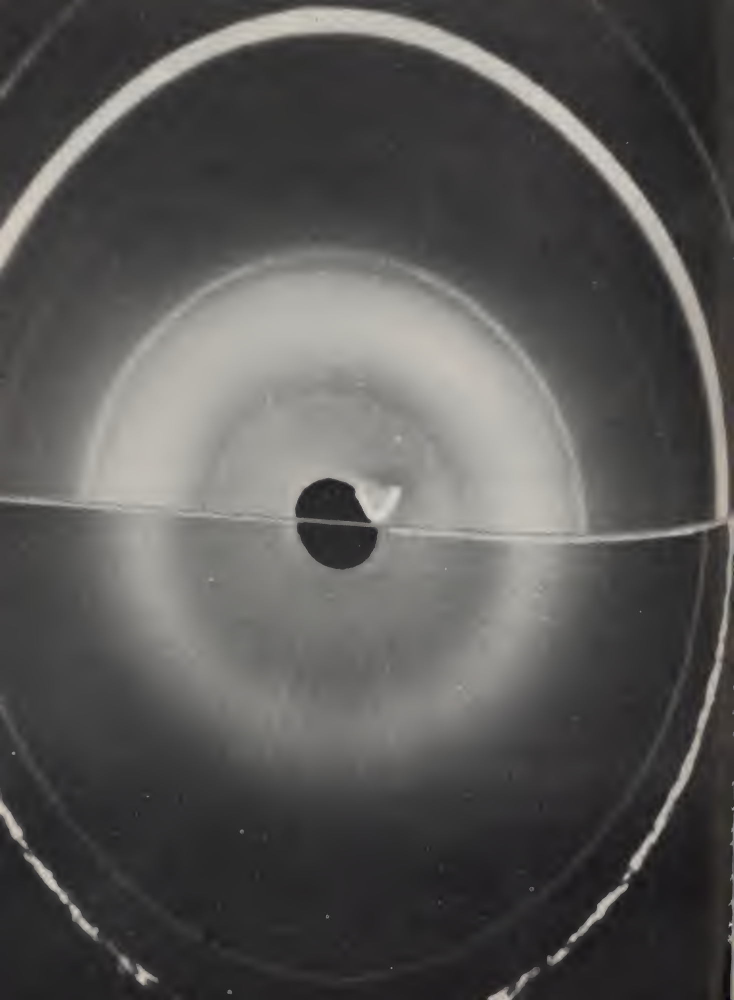
- OUR LABS

SCHOOL OF ENGINEERING

THE GEORGE WASHINGTON UNIVERSITY

MAY 1957



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SCHOOL OF ENGINEERING, THE GEORGE WASHINGTON UNIVERSITY

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Artist's conception of the earth satellite in its journey through space. *U.S. Navy Drawing*

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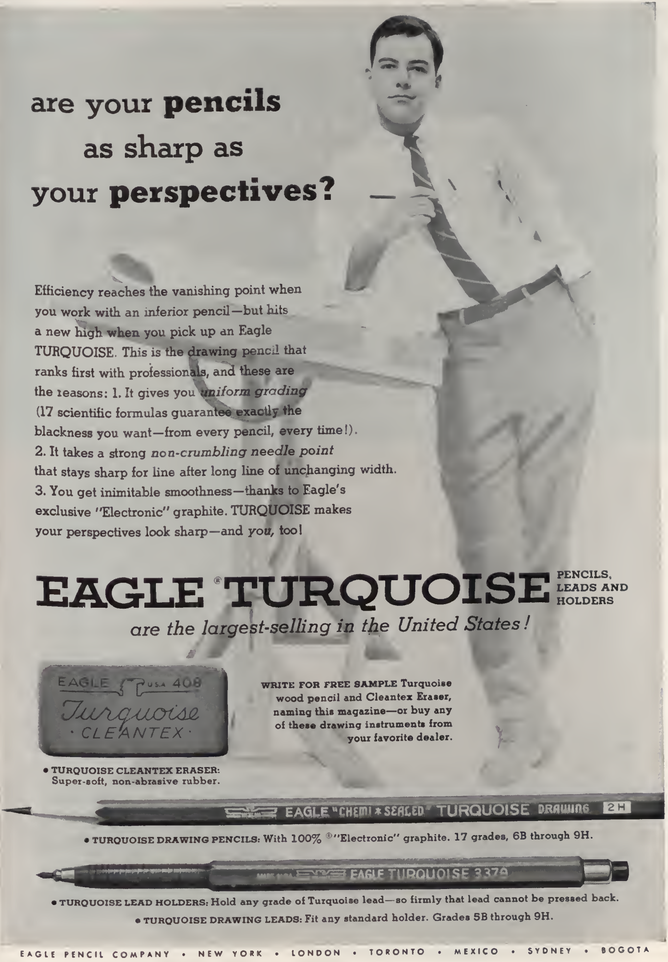
X-ray diffraction pattern obtain from Borozon crystals. (See Page 30)

Published at the George Washington University by direction of the Engineers' Council. Published six times during the school year in October, November, December, March, April, and May. Entered as second class matter March 6, 1951, at the Post Office at Washington, D. C., under the act of March 3, 1879. Address communications to Mecheleciv Magazine, Davis-Hodgkins House, George Washington University, Washington 6, D. C. or telephone STerling 3-0250, Extension 528.

CHANGE OF ADDRESS: Send your new address at least 30 days before the date of the issue with which it is to take effect.

Subscription Price: Two Dollars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EDITORIAL

A DEFENSE OF ENGINEERS

The engineers' star is rising further and further in the professional universe as engineering accomplishments gain greater and greater recognition. Every day, the prestige of the profession increases as the realization reaches the public that a greater number of products contributing to progress, enlightenment, and comfort, are direct results of engineering endeavor.

Despite these many avenues of acclaim, the individual engineer has his everpresent detractors. All too often "engineer" is associated with an over-specialized social cactus, unable to meet his rendezvous with the Muses, an automaton guided only by a fixed number of rigid physical laws.

Sometimes, the *individual* earns this concept. More often, it is attached to him by a social clique possessing the ability to criticize that which they do not comprehend.

Perhaps the most fluent criticism surrounds the lack of knowledge a majority of engineering personalities possess in the field which is classed as liberal arts or humanities by the educators, and lumped into the term "culture" by the masses.

Undoubtedly a thorough study of the arts, a background in history, an appreciation of literature, and a relation with the social sciences is a worthy accomplishment. For some reason, these components of the complete composite of human knowledge are likely to be regarded as the ultimate. Physical science is excluded as a vulgar stepchild, a mundane hodgepodge of necessary evils. Too often an association with the humanities is accepted as the prime prerequisite for the "rounded" personality.

For this reason, numerous attempts have been made to place at least a veneer of this culture upon the engineer by inflicting liberal arts subjects upon him. These subjects must be injected into a curriculum already brutally filled with time-consuming technical courses. The obvious result is that the engineer must slight these subjects in order to apply an adequate amount of time to his major. He feels, therefore, that he is saddled with a course of questionable interest and value; his professor feels he is involved with an unattentive student; his classmates gain an impression which tends to persist, that the engineer is an overly busy, preoccupied soul too limited in scope to develop an interest.

Obviously, the engineer must maintain as broad an outlook as possible, for in so doing, he increases both his social and professional stature. The responsibility for doing this must rest on the individual, however, for attempting to accomplish simultaneous education in two fields will only detract from both.

Other criticisms center around the supposition that the engineer is semilliterate, inarticulate, and antisocial. To say that the engineer is semilliterate is absurd. Engineering education requires the composition of a great many voluminous reports. A survey of any technical publication will display reams of material compiled by engineers. The real complaint is that all too frequently a reader may fail to comprehend the plane of engineering discussion, and because it is not understood, it is assumed to be an illiterate style.

The assertion that the engineer is antisocial is likewise unjust. Perhaps on a university level such an impression is understandable. The student engineer is perpetually drafing on a checking account of time which is substantially overdrawn. He is not often permitted the privilege of lengthy philosophical discourse, extended dalliance, or excessive joining, and for this reason is often branded a nonfunctionary.

On the basis of available spare time expended, however, it is felt that the engineering student has proven himself more than capable of meeting his extracurricular obligations.

On the professional level also, the engineer has organized societies of benefit both to the profession and mankind as a whole. Indeed, among the professional groups, the engineering societies have been the most active in the dissemination of information and the least active in the dissemination of self-interest propaganda.

Engineers as individuals have displayed their abilities as leaders, both in industry and government. The individual engineer is usually politically interested, alert, and informed. Although the engineers may not be as active politically as some of the professions more related to the legislative processes, they are none-the-less interested in the perpetuation of a proper form of government nationally and locally.

The case against the engineer bears no more weight than the consideration that a great many of our contemporary intellectuals are lacking any scientific background, even though the present society displays increasing dependence upon scientific endeavor and scientific thought. Although a number of groups are allowed to specialize with no criticism, it has become fashionable to criticize science for specializing, even though it is creating the most substantial contribution. A great deal of the censure the engineering profession receives is a result of engineers' attempts to do a job well. Unfortunately, the scope of engineering work is often rigorous enough to produce over-concentration and preoccupation, but society must accept this as readily as it accepts engineering progress.

D. A. L.

AROUND THE WORLD FOR 80 DAYS

by Morrow Moore
B. M. E. '57

During the 1957-58 International Geophysical Year, science hopes to gain much new knowledge of the earth, its atmosphere, its oceans, and solar and cosmic phenomena. Overlapping these investigations will be two major projects: rocket studies of the upper atmosphere and the earth satellite program.

Rockets are at a disadvantage in high altitude research because their time spent at any one altitude, and even total flight time, is relatively brief. Rockets are not in themselves adaptable to long term studies, and are therefore ineffectual in investigations of cosmic ray intensities, fluctuations in ultraviolet and X-ray radiation, particle streams, and the current rings which circle the earth. These present the most important problems of the upper atmosphere.

Only the earth satellite could provide these important, long term data. Orbited at high altitudes, for appreciable periods of time, the satellite would permit measurements otherwise unobtainable.

The leader of the Satellite project displays a full scale model. ***U.S. Navy Photo***

The world's velocity and altitude record for a long range rocket was set by a two-stage missile of American manufacture, the Bumper Wac. The Bumper Wac reached an altitude of 250 miles and attained a peak velocity of 9,000 fps. while carrying a payload close to that which is contemplated for the satellite vehicle, The Vanguard. Now science wishes to better this record in order to raise the satellite to an altitude of 300 miles and provide the additional 25,000 fps. necessary to maintain an orbit.

THE VEHICLE

The Vanguard launching vehicle is a finless three-stage rocket, approximately 72 feet long, and 45 inches in diameter at its widest point. Gross takeoff weight with propellants is about 11 tons.

The first two stages will be guided and will lift the unguided third stage to orbital altitude. At third stage burnout, some 1,500 miles downtrack from the launching site, the satellite will be pushed from the third stage rocket.

The instrumentation in the satellite will be subjected to severe conditions during the ascent. All the instruments packed in the satellite sphere must be built to withstand vibrations greater than any other recorded during powered flight. Also temperatures in the nose cone, covering the satellite, will be raised by aerodynamic heating to over 1,000 degreees F.

Guidance

Guidance is provided by a control system located entirely within the second stage. The system will take command on the launching platform and position the first and second stage motors to keep the vehicle on its programmed course. Liquid propellant rocket motors for both the first and second stages will be gimbal mounted and free to turn up to five degrees in any direction about the rocket's longitudinal axis.

The particular control unit used is a three-axis inertial guidance system, consisting basically of three gyros, which memorize the vehicle's three heading references —roll, pitch, and yaw. The control unit supplies guidance instructions to a magnetic-amplifier autopilot to control the Vanguard vehicle's course. Pitch and yaw gyros control the direction of thrust of the first and second stage rocket engines through the autopilot. Swiveling exhaust ports, or "jet reactors," located outside the rocket, are controlled by the roll gyro to correct for roll. To control the ascent course, the pitch gyro axis is rotated to a new heading.

The inertial reference system can measure deflection rates as small as 0.00003 of a degree per second.

THE THREE STAGES

Only fourteen per cent of the weight of the Vanguard is given to the airframe structure; the remainder consists of the propellants, propulsion units, and the control system.

The first stage is a liquid propellant rocket similar to the Viking but with substantial improvements and slightly longer — about 45 feet overall. Engine and accessories are located at the base with two propellant tanks filling the remaining space. The tanks have their aluminum walls integral with the airframe skin.

The first stage is finless. Electro-hydraulic controls that position the motor have the necessary response to stabilize a finless airframe in pitch and yaw. Roll control, as mentioned previously, is provided by small auxiliary jet motors.

A seven to eight ton propellant load of liquid oxygen, and a mixture of ethnol, gasoline, and silicone oil is transferred by turbine-driven pumps, the turbine being powered by hydrogen peroxide. The turbine also drives a hydraulic pump for the controls. The propellants are pressurized with helium and are consumed in 140 seconds.

In summary, the first stage is essentially a guided liquid-propellant booster that provides most of the energy to raise the remaining stages to orbital height.

Attached to the forward end of the first stage is the second stage, 31 feet long and 32 inches in diameter. Contained here is the Vanguard controlling system, which again provides yaw and pitch control for second stage powered flight by positioning a gimbal mounted motor. A master sequence controller in stage two, times all the major inflight operations, such as ignition and cutoff of various stages and stage separations.

Powering the second stage is a liquid propellant motor, using one and one-half tons of nitric acid and unsymmetrical dimethyl-hydrazine. They will be fed directly to the motor from high pressure tanks, integral with the airframe's skin and pressurized with helium. Because of the corrosiveness of the fuels, the tanks are of stainless steel.

The third stage is a solid propellant rocket that is unguided. During burning, it is maintained in a stable orientation, approximately parallel to the earth's surface. Several propellant formulas are being tested but a final choice has not been made. The payload, presently viewed as a 20 inch sphere, is attached to the front end of the third stage and may be separated when orbital velocity has been attained. The third stage must reach orbital velocity and when separated from the payload will be a satellite itself.

THE ASCENT TRAJECTORY

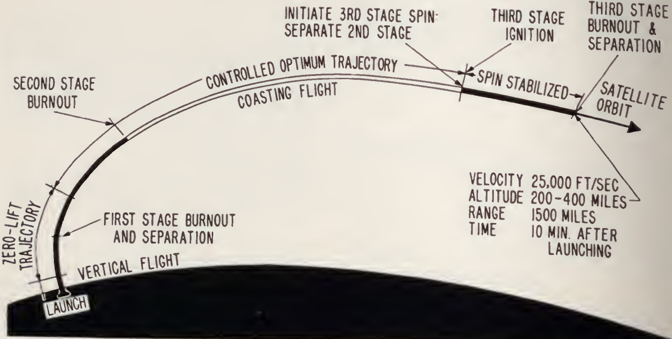
The Vanguard vehicle will begin its ascent at Patrick Air Force Base in Florida. At the latitude the earth's rotational velocity, which will be the initial velocity relative to free space imparted to the launching vehicle, is 1,340 fps.

The three stage vehicle takes off vertically under the first stage power and, as it ascends to first stage burnout, tilts progressively toward the east. At burnout, about 36 miles above the earth, it has a horizontal velocity of 3,500 mph and is inclined at an angle of about 45 degrees. The first stage now separates and coasts to an impact about 230 miles from the launching site.

Immediately upon first stage separation, the second stage ignites and proceeds under power on a progressively more inclined path up to 140 miles.

Housed in the second stage nose is the third stage and the satellite. The nose cone protects the delicate satellite from aerodynamic heating, which the sphere would encounter if exposed during the first and second stage ascent through the atmosphere. Early in second stage powered flight, at about 60 miles altitude, the nose cone is jettisoned, revealing the satellite.

At stage two burnout, 140 miles above the earth, the vehicle has a vertical velocity great enough for ascent to the 300 mile altitude and horizontal velocity of one-



half the required orbital velocity. No separation at second stage burnout occurs, and the second and third stage combination coasts forward a distance of about 700 miles in ascending to the 300 mile third stage projection altitude.

During the second stage coasting flight, several jet reactors provide complete control of orientation and the following functions are performed to ready the satellite for launching: the two-stage vehicle must be brought to the correct orientation for the third stage firing parallel to the earth's surface, and then the third stage is rotated and fired.

Spin is imparted to the third stage vehicle about its longitudinal axis by a pinwheel arrangement of jet motors. The rotation is vital if the satellite is to maintain stable flight as it moves into the orbit.

The third stage is separated and fired at the zenith of the second stage. It is necessary that the third stage be projected as horizontal as possible into the desired orbit to insure an orbit. An error of one and one-half degrees from the true horizontal will mean either a short satellite life or relocation of the observation stations.

All last minute commands given by stage two must be prior to third stage ejection, since from this point no further control of the vehicle is possible. Separation of the payload will have been previously armed and timed to occur at third stage burnout. The rocket motor must be separated from the satellite at this exact time or heat from the motor will penetrate the satellite and affect the delicate instrumentation.

THE ORBIT

Because of air density, the closest point in the orbit must be at least 200 miles from the earth. The actual chosen orbit is a nominal circle 300 miles in altitude, but errors in the launching height, angle, and velocity will result in an elliptical orbit that should lie between a perigee of 200 miles and an apogee of 1400 miles. If the resulting orbit lies within this range, the launching vehicle will have accomplished its mission.

The more the satellite dips into the atmosphere, the less will be its lifespan. Based on present estimates of air densities, calculations indicate that if the vehicle starts to orbit below 100 miles, the satellite would not make one complete revolution of the earth. At 200 miles, its life could be two to four weeks and, during this period, it could provide more than enough information to make the entire project worthwhile. A satellite might exist in a 300 mile orbit for one year.

From the standpoint of viewing solar and stellar spectra, the orbit of the satellite should be as high as possible. However, drag determinations require that the orbit be just within the atmosphere. For these and other experiments the vehicle needs no instrumentation, but it must be visible enough to make possible accurate measurements of its position.

In the rare gas at orbital altitude, a body the size of the satellite will find its own temperature, the controlling factors being the absorption of solar radiation and infrared radiation from the earth, balanced by the self-radiation of the satellite. The temperature can be somewhat controlled by the type of surface coating used. It is estimated that, in successive passages from the sun-

Artist's conception of the Vanguard launching vehicle.
U.S. Navy Photo

lit to the shady side of the earth, the outer skin will go through a range of 100 to -70 degrees F. Insulation will limit this range for the instruments to a 70 to 40 degrees F span.

THE SATELLITE PAYLOAD

There are three leading possibilities for a satellite payload, and probably not any one will be exclusively used but rather a variety will be released.

The first is a rigid sphere, 20 inches in diameter. This shape would have good optical visibility and is the best for an accurate determination of atmospheric density from the observed drag data.

Second is a cylinder, 18 inches long and six inches in diameter, which would contain a maximum of onboard scientific apparatus and a minimum of structural weight. However, this shape would have poor optical visibility.

Inflatable spheres up to five feet in diameter are a third possibility. They would have good optical visibility and are well suited for drag observations, but they would have little or no instrumentation.

The payload must be chosen wisely because a price is paid in terms of velocity lost per pound of payload. For the Vanguard, this number is estimated at 80 fps per pound. In many missile systems, a performance less

(Please turn to page 39)

TIDE IN—
POWER OUT

by Joe Greblunas
B. E. E. '57

The earth as it rotates about its axis possesses a vast amount of kinetic energy. A portion of this energy of spin appears in a recognizable form as part of the earth's winds and ocean tides. The gravitational effect of the moon, principally, but to some extent that of the sun, causes the movement of the oceans.

Tidal energy has long been of interest to engineers. The tidal energy is there; you can see it, even hear it. It is perpetual: it is free. It seems to be close at hand, and yet, it has not been put to any practical use.

To obtain a better understanding of a tidal hydo-electric power plant, consideration will be given to the schemes developed, the problems involved and the cost of a tidal-hydroelectric power plant as compared to a steam power plant of the same rating.

Through the years, there have been many schemes developed in harnessing the tides. Some of the most important are: The Float System, Tidal Stream System; The Compressed Air System and The Basin System. As it will be shown later, the Two-Basin System is the most practical, therefore consideration will be given to the major problems involved, such as the movement of ice in the basin, the settling of silt at the bottom of the basin, the deterioration of parts permanently and periodically submerged in sea water, and also subnormal neap tides.

The Float System

The float system consists of a weight placed in a tidal stream. The rising and falling of the weight does work on a mechanical system of levers and gears. The mechanical energy is transmitted by these levers and gears to the generator which in turn converts the mechanical energy to electrical energy. The slow movement which .he tides possess would take enormous gears and levers to rotate the generator to any practical speed. With these low speeds the generator output would be of a very small value. The mechanical difficulties and low power output are enough to make this system impractical

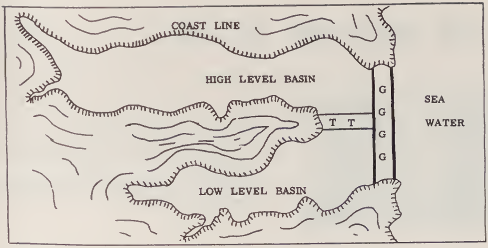
The Tidal Stream System

The tidal stream system consists of paddle wheels placed in a raft anchored in a tidal stream. The movement of the tide provides the rotation of the wheel. As in the float system, the mechanical gears and shafts transmit the tidal energy to the generators. Although the wheel rotates at a faster speed than the gears in the float system, the rotation of the generators cannot be increased to any practical value without incurring mechanical difficulties.

The Compressed Air System

The compressed air system is that of direct compression of air in a closed chamber. As the tide rises from neap tide to spring tide, (The phrases "neap tide" and "spring tide" are used to denote the minimum and maximum tidal effects in any one tidal cycle) a moveable piston is forced upward, and its upward action compresses the air in the chamber: no air is compressed on the downward stroke. As the piston is raised, the compressed air has the ability to do work. The amount of power output from this chamber depends upon the height and the diameter of the cham-

A sketch of a single basin system showing the placement of the gates and power turbines.



A sketch of the two-basin system showing the optimum placement of gates and turbines.

ber. The chamber would have to be as high as the head of the tide. The compressed air may be discharged onto turbine blades which in turn drive the generators. With this system it is seen that the chamber would have to be quite enormous in order to get any usable amount of energy. There will also be periods of no power at ebb tide. This system, though giving a better result than the float or stream systems, still gives a minimum power output. Considering the cost involved, the output is far too small to render the system at all practical.

The Basin System

The basin system has been described as "one, in general, of enclosing an estuary from the ocean by a dam or dams with gates." The basin system comes in two varieties, of which the single basin system is the simplest. In the single basin system, an estuary is enclosed from the ocean and the basin thus formed is filled when the tide rises. When the maximum level of the basin is reached, the gates are closed. The water is held to this level until, on ebb tide the difference in head reaches some chosen amount, usually "8 to 10 feet." The entrapped sea water is then allowed to flow through hydraulic turbines and back into the sea. With this system it is seen that there would be periods when the generating plant would be shut down, resulting in no power output. Plant shutdowns would occur twice a day, which is the biggest disadvantage to the system.

The second type is a two-basin system in which two estuaries are enclosed by dams. One basin is used as a high level basin and the other as a low-level basin. A dam is built between the two basins, and the turbines are located on this dam. With the proper timing of opening and closing of gates, this system may be made continuous.

It may be well to go through one complete cycle of operation. Starting at spring tide, the high-level basin is full to capacity, and the low-level basin is at some point below the high-level basin. The tide now begins to ebb. The intake gates in the high-level basin are closed. The turbine gates are now opened and the water is allowed to discharge through the turbines and into the low-level basin. The rate of water flow is regulated so that there is always enough water for one complete tidal cycle and to give the effective head mentioned previously. When the ebbing tide reaches the water level of the low-level basin, the low-level basin's discharge gates are opened, and the tide and the low-level basin's water ebb together. Keep in mind that the high-level basin is continuously discharging into the low-level basin. When neap tide is reached, the low-level basin is at its minimum, and its discharge gates are closed. The tide now begins to rise, and it continues to do so until it reaches the water level of the high-level basin, which is still discharging, then the intake gates are opened in the high-level basin. The tide and the water in the basin are now allowed to rise together until spring tide is reached, and then the intake gates are closed. The cycle now repeats itself.

The power output of the two-basin system varies only with the size of the basins and the head of the tides. The output power of the two-basin system may go as high as 300,000 horsepower, which could be of practical use.

Since the two-basin system is the only one in which a practical amount of continuous electrical power can be made available, from here on this entire discussion will be concerned with the two-basin system.

Places Considered for Tidal-Hydro Electric Plant

In the past, many tidal power plants have been the subject of discussion and speculation, but in only four instances, so far as is known, have any organized investigations and studies been attempted.

In England, the Severn River has been the site of investigation for a tidal hydro-electric plant.

In Canada, the estuaries of the Petitcodiac and the Memramcook Rivers, which empty into the Bay of Fundy, have been investigated for a tidal hydro-electric system.

In France, the La Rance River has been recently investigated as a possible site for a tidal hydro-electric plant.

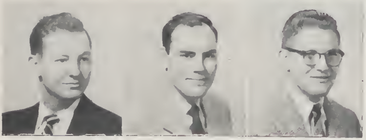
Here in the United States, the Passamaquoddy project went through a costly investigation.

In each of these four areas, when the final reports were made, it was shown that the harnessing of the tides was not economically feasible. All, except the Passamaquoddy project were tabled for future consideration.

At the time of the Passamaquoddy investigation, the United States was in a period of depression, and the government was anxious to create jobs. One hundred million dollars was appropriated for the tidal project, of which five million dollars was spent for actual construc-

(Please turn to page 40)

— THE GRADUATES OF 1957 —



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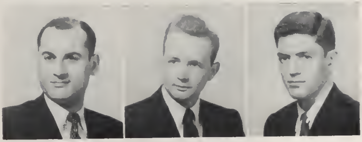

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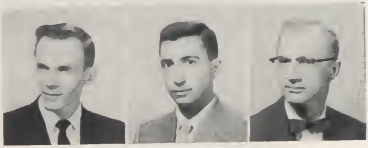

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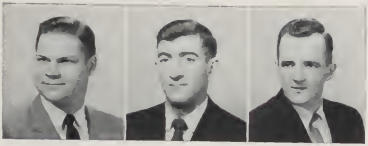

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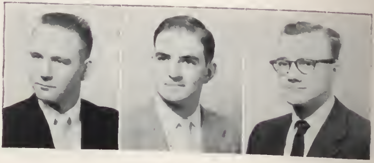

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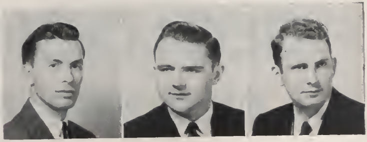

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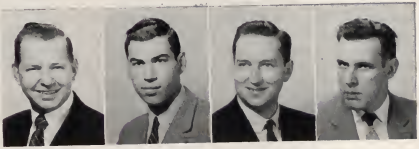

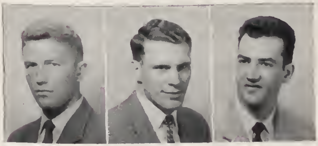

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GEOLOGIC MAPS
AN ENGINEERING TOOL

by Dick Haefs
B. C. E. '58

Engineers have long recognized the usefulness of previously-published maps in reconnaissance and preliminary surveys for engineering projects. Although some new work is invariably necessary, be it surveying or aerial photography, often maps can be found that will save much time and expense. The value of such maps depends, of course, on their availability, amount of detail, scale, and accuracy. The engineer should, and usually does, investigate the availability of such maps as one of the first steps in any field project.

Topographic maps are certainly the most useful for this purpose. Besides showing the cultural development and drainage patterns of an area, topographic maps also illustrate the land forms and relief by means of contours, shading, hachures, or other means. Such maps can answer many questions for the engineer. If adequate topographic maps are obtainable, much tedious preliminary field work can be eliminated. It sometimes happens that a map, because of its broad coverage, shows up difficulties that are not apparent on the ground.

Topographic maps are universally accepted as having an important place in these preliminary investigations. However, engineers all too often overlook an even more valuable refinement of these tools. How many engineers make full use of published *geologic* maps in their reconnaissance work? Authorities indicate that the engineering profession is not taking full advantage of these powerful aids.

The difficulty seems to be that in general the engineer's knowledge of engineering geology is often somewhat skimpy. His education in this important subject probably ended with properties of materials and soil mechanics, or was passed over lightly. However, a sound knowledge of the geological sciences is definitely an asset for any civil engineer; perhaps it should be stressed more in the schools.

The engineer who is "up" on his geology can anticipate many difficulties that those not so equipped will overlook. He does not rely on empericisms or "rules of thumb;" his knowledge is based on fact. He is able to see the relationships and conditions of earth materials and earth structures far better than those who must depend on previous experience and graphs and charts alone.

The geologically minded engineer does not hesitate to use geologic maps to the fullest extent. Others can learn to use this tool without too much difficulty. A study of basic geology and geologic map interpretation is highly recommended for those anticipating much preliminary planning work during their engineering careers.

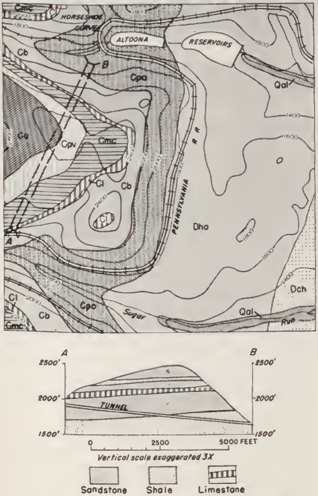
The geologic map usually is printed on a topographic base, so that the geological relationships shown thereon are clearly tied in to the configuration of the land. On the geologic map various rock units and geologic formations are defined, described, and delineated, as well as other features such as faults, attitude of beds, geologic structure, etc. A study of a good geologic map can tell the reader more than he could find out by himself by visiting the area.

Many types of problems familiar to the engineer can be solved, at least partially, by interpretation of these geologic maps. Site selection is good example. Although a geologic map certainly does not eliminate field work, it does supplement it, and eliminate much needless effort. Usually some sites can be dropped from serious consideration, solely on the basis of data from such a map. However, it is best to field check these solutions, especially where there is any question as to the map's reliability. Although aerial photographs and plane-table surveys have their places in reconnaissance work, a geologic map often can save a lot of trouble.

Geologic maps can also be useful sources of information on foundation and excavation conditions. However, knowledge is needed of the properties and conditions of the units shown on the map before a reliable evaluation can be made. A study of more basic data is helpful here. With proper training an engineer can often recognize formation's properties from its name and description.

The search for suitable and economical construction materials can often be expedited by the study of geologic maps, especially maps of surficial geology. These maps may indicate to the engineer a nearby, convenient source of gravel, or sand, or sound rock for masonry. A search on the ground might take days, while careful examination of a good geologic map might solve the problem in an hour.

Some geologic maps give helpful information on the drainage conditions and water supply, both surface and underground. This sort of data is invaluable in almost any engineering project. For example, if a map indicated that a certain formation was extremely porous, the engineer would make special investigations before locating a reservoir there, and probably would call for special precautions or abandonment of the site.



A TYPICAL ENGINEERING PROBLEM

Problem: Report on conditions to be expected in constructing a large railroad tunnel 7,400 feet long, connecting points A and B, on Pennsylvania Railroad main line just south of Horseshoe Curve.

Solution: At portal A, tunnel will enter massive gray sandstone. It will continue in this rock 3,650 feet, where soft varicolored shale, nearly flat bedded, will be met. Remaining 3,750 feet of tunnel will be in this shale. Rock at both portals is badly weathered to depths of 50 feet. Recommendations:

1. Heavy lining required for first 50 feet at both portals.
2. Both portals should be protected against landslides and rockfalls.
3. Sandstone in first 3,650 feet will be easy to drill and blast; will require no support except at portal. Adequate drainage should be provided, as sandstone is porous and will probably yield much water.
4. Shale in at least 3,750 feet of the tunnel will be easily excavated. Cave-ins are likely to occur; continuous support of walls and roof is essential during construction. Most of shale portion will require permanent lining.

Besides the usual general-purpose geologic map, there are a wide variety of special - purpose maps which show specific phases of geologic data. Some engineering geology reports are designed specifically for the purposes outlined above. Their construction is often considerably different from that of the ordinary geologic map, and their usefulness is often limited to the narrow field for which they were designed. Such maps, although extremely helpful, are only rarely available. However, the possibility should always be looked into. If by chance a special-purpose engineering geology map can be found, the engineer has a veritable wealth of data with which to work.

Unfortunately, really good up-to-date geologic mapping covers a relatively small portion of the country. However, the possibility that an adequate map exists should never be overlooked. One of the most prolific sources of geologic maps and other data is the U. S. Geological Survey. The Survey's map distribution office in Washington is close by the University, and is located in the GSA Building at 19th and F Streets. Index maps showing the extent of geologic mapping in any particular area can be obtained there. Other offices are located across the country. More detailed bulletins, professional papers, etc., can also be obtained from the Geological Survey, and may provide the engineer with just the right answer to his problems.

Geologic maps and information are available from any number of other sources, too. Most of the States have Geological Surveys, many of which have made very detailed investigations of the geology within the state. Also the Geology Departments of many universities can be helpful. Every major city also has geological consultants, who are trained to solve some of the more involved problems of this nature that are encountered by engineers.

In 1953 the U. S. Geological Survey published, as an educational aid, a special folio entitled "Interpreting Geologic Maps for Engineering Purposes." This remarkable publication clearly illustrates the points made here. It consists of a set of six maps, all bound together with some descriptive text, all of the same area, namely the Holidaysburg quadrangle in southeastern Pennsylvania. There is an ordinary topographic base map, a general-purpose geologic map, and four specialized geologic map showing a variety of engineering details. Also a number of sample problems are given which demonstrate how engineering problems can be answered by such maps. One example, for instance, shows what sort of excavation work would be required to construct a tunnel that would eliminate the famous Horseshoe Curve near Altoona.

This folio would be of considerable interest to any student engineer, regardless of his background in geology. It is available for $1.75 at the Geological Survey office in the GSA Building.

The engineer, then, whether student or professional, would do well to look into geology as a science, and learn all he can about it. Geology is a tool as valuable to him as his knowledge of calculus. Once he has a good working knowledge of the subject, he will find that geologic maps will be a great boon to him and his work.

CREATIVE ENGINEERING

by George Hinshelwood
B. M. E. '57

Cartoons by Author

Each morning, in this country alone, we have seven thousand more people to feed. As the population increases, our problems, in numbers and complexity, increase at a greater exponential rate.

Two-thirds of the world still goes hungry; mankind has a long way to go to reach a Utopia.

Men have always had difficulty getting along together; interrelationships and interdependencies make this difficulty more and more potentially destructive.

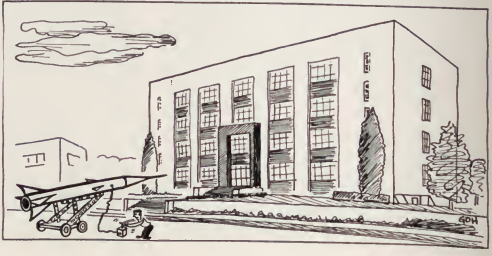
The above are some general-type reasons why tremendous creative effort must be made, in all fields.

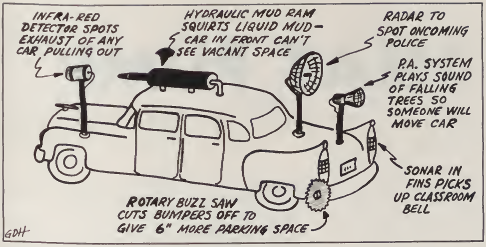
Specifically from an engineering standpoint, the acute shortage of trained personnel, coupled with the increase of research and development plans, requires a method of supplying additional manpower. Increasing the creativity of the engineer and scientist is one obvious method. Industry is turning its attention to the actual dollar cost of ideas developed too late, ideas not developed to the fullest potential, and ideas not developed at all. From awareness of the needs for creativity are coming many courses, training programs and written material by government, industry and schools. For example, General Electric has an intensive creative engineering program. It is a two-year course given to carefully selected employees, and includes teaching — through classroom and actual work problems—engineering fundamentals, organized approach to engineering problems, knowledge of creative techniques, reduction of ideas to practice and development of creative attitudes. The course is rigorous for the men — 35 weeks of school a year, 20 hours per week of work problems assigned on personal time — and expensive for the company, but it has continued for twenty years as a paying proposition. Many other companies have creative training program of varying degrees. M.I.T. holds excellent full-scale seminars (from which material for this article was gathered) on the subject of creative engineering and product design.

Creative engineering is not something obtained by set rules for individual problems or by gimmicks. It involves more than the mechanics of the trade. It involves basic concepts of self and society and the related problems, and a generalized study of what constitutes creativity. First reaction to many of the techniques is "Everybody knows this," but it is the practice, the organized and constant attention to the techniques of creativity, which make the difference between a problem solved or not solved.

What is creativity? Professor John E. Arnold, of M.I.T., defines it as "primarily a mental process whereby one combines and recombines past experience, possibly with some distortion, in such a fashion that the new combination, pattern or configuration *better* solves some need of mankind. In addition, the end result must be tangible, something you can see, feel, or react to in some way; it must be forwardly oriented in time and it must have synergetic (the whole greater than the part) value."

"Get big ideas . . "





THE IDEAL STUDENT CAR—
"A creative design should serve some need of mankind."

In a study of creativity, we start with the basic premise that all men are born with potential of varying degree for creative action and further that it it is possible to increase realization of this potential through understanding, practice and exercise. J. A. Anderson of AC Spark Plug Division of General Motors reports that in all the groups trained in their creative engineering program. ability to produce ideas was improved by 40 per cent.

An interesting point was that the lower half of the groups improved 60 per cent while those whose prior tests showed maximum ability increased by 25 per cent.

Certain factors are unique to the creative personality: problem sensitivity, fluency, flexibility and originality. Some speak of problem sensitivity as "openess to experience." It is being aware that a problem exists, looking for the unexpected and finding it. It is also associated with problem statement, and the ability to ask meaningful questions. Problem statements may limit or free the imagination of the solver. They may precondition his thinking along narrow lines that preclude desirable solutions. The first step in a creative act is being sure that we know exactly what we are trying to do and what goal we are trying to reach. When looking for new ideas or new approaches, you should state your problems in as general terms as possible. For example, if you state your problem as one of designing better toasters, you will probably get cheaper, prettier, and more efficient toasters. However, not until you define your problem correctly and generically as that of heating, browning and dehydrating the surface of bread, will you get new solutions. Thus it is well to start out with a very broad viewpoint and eventually narrow the problem down. The creative designer should look into all possible approaches; should formulate problems and subproblems until he finds a solution that satisfies as many of the prime goals of the initial problem as time and expense allow.

Very closely related to problem statement is semantics —the meanings and effects of the words we use. We should avoid vague language, terms such as "mind," "emotions." Value-type questions such as "Should we do this?" are better replaced with: "What would happen if we do this?"

The creative personality has more ideas per time unit. This fluency, however, can be halted by simultaneous evaluation of ideas. Ideas cannot be rejected too soon or discrimination made too severely.

Flexibility is an ability to change pace. It is reflected in the wide variety of approaches that the creative person chooses to investigate. For example, when people asked to name all the uses for common red brick can make long lists of uses. there is fluency. If all the uses fall into the category of construction there is little flexibility. There are some fourteen categories—doorstops, drowning cats. hotwater bottles, paint pigments obtained from groundup brick. etc.

The creative person has originality; he makes more novel and original combinations than the non-creative person. He is able to bring together usually incompatible ideas and form new and good combinations; he has a strong spirit of inquiry and an ability to relate ideas in one area with similar ones in another. He is able to utilize Aristotles' Three Laws of Association: by seeing similarity, or by contiguity of ideas, nearness in space or sequence in time.

In addition to these four mental attributes, certain emotional attributes are necessary for creativity. First of all, a man must be motivated, from within or without, before he will attempt to solve a problem. Other emotional qualities are willingness to take a chance and to be daring with new ideas, self-confidence in ability to solve problems, and drive, since ideas are no good if not followed through to a workable stage.

However. all the above qualities of the creative person can be rendered useless by certain factors which tend to inhibit and prevent productive activity. These factors are loosely grouped as perceptual blocks, cultural blocks, and emotional blocks.

Perceptual blocks refer to all the ways in which we fail to get true, adequate and relevant information about the outside world. They include such things as inability to define terms. failure to use all of the senses in observing, difficulty in seeing remote relationships. difficulty in not investigating the "obvious" and failure to distinguish between cause and effect.

Cultural blocks arise from the influence that other people and the things that they have created have on our thinking. Some cultural blocks might be desire to conform to an accepted pattern, too much faith in reason and logic, belief that indulging in fantasy is a waste of time.

(Please turn to page 41)

THE HEAT PUMP

by Joe Mast
B. M. E. '57

For years, science has been seeking ways of applying the thermodynamic principles of the refrigeration system to a device which would supply both heating and cooling effects. The concept of such a device is not recent, its principles were pointed out by Lord Kelvin over a century ago.

The application of this concept in the form of the present day heat pump offers many intriguing possiblilities. It presents a method of heating and cooling commercial and residential installations without the use of a combustible fuel, and with the installation of but one unit. Increased importance has been attached to its development because of the rapid depletion of our available fuel resources, paralleled by increasing demand for year around comfort conditioning.

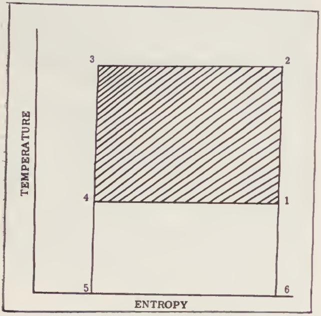


Figure 1—The Carnot Cycle

The Swiss are the acknowledged leaders in modern heat pump development, for it is ideally suited to their needs. It permits utilization of their most abundant resource, hydo-electric power, and simultaneously reduces the drain on their limited supplies of combustible fuel.

ELEMENTARY HEAT PUMP OPERATION

The mechanical equipment of all heat pumps is basically a standard refrigerating plant with some means of reversing the cycle so that either heating or cooling may be supplied to the space to be conditioned.

The elementary heat pump system consists of a compressor used to raise the pressure and temperature of the refrigerant vapor, a condenser from which heat is extracted from this refrigeration medium, an expansion valve used to lower the pressure from the high-pressure or condenser side to the low-presure or evaporator side of the system, and an evaporator in which heat is absorbed by the refrigerant from some source.

In operation the compressor discharges the refrigerant at a high temperature and pressure in the vapor state. The vapor then passes to the condenser where it is condensed to a liquid giving up the latent heat of condensation. From the condenser the liquid passes through the pressure reducing valve to the evaporator where it changes into the vapor state by absorbing the latent heat of vaporization from the external source. To complete the cycle the low pressure vapor returns to the compressor to be recirculated.

The index of performance of the heat pump is called the "Coefficient of Perfromance" (COP) and is the ratio of the heat rejected to the mechanical work which must be expended to deliver that amount of heat.

The Carnot cycle (see figure 1), although not possible in practice, is a means of studying the relative importance of factors effecting the COP. The heat absorbed by the system (refrigerating effect) is represented by the area 1-4-5-6. The heat rejected by the system is represented by the area 2-3-5-6. The energy added ideally by the compressor as work to accomplish these effects is represented by the area 2-3-5-6, minus area 1-4-5-6 or the area (shaded) 1-2-3-4.

Therefore:

$$\text{COP for heating} = \frac{\text{heat rejected (2-3-5-6)}}{\text{work (1-2-3-4)}}$$

$$\text{COP for cooling} = \frac{\text{heat absorbed (1-4-5-6)}}{\text{work (1-2-3-4)}}$$

The design of the basic heat pump differs only in the heat source utilized and the heat transfer medium.

AIR TO AIR SYSTEM

The air to air design is the most popular for units of limited capacity. The largest unit is in the neighborhood of 10 hp. General Electric and Westinghouse have utilized this principle in their packaged unit design.

The air to air unit (see figure 2) has the advantage of compact design utilizing the package unit which re-

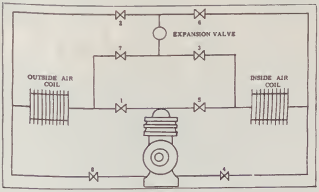


Figure 2—The air to air system

quires no plumbing connections. The main advantage of this unit is the source of heat which is the outside air. It is immediately evident that this unit can operate only in milder climates where the outside air temperature stays above freezing. With a lower temperature the COP is greatly reduced and frost accumulation on the coils may become prohibitive.

The system may be reversed as shown in figure 2 or a system of ducts and dampers may be used which has the advantage of a one-way refrigerant flow which eliminates the costly control valves.

WATER TO AIR SYSTEM

The source of heat for this system is well water which has the advantage of maintaining a relatively constant year around temperature. The heat source may be a well, a lake or the local water mains. Because of the constant heat source, a high COP may be maintained. (See figure 3.)

It is interesting to note that a Swiss skating rink uses this type of system. The city water main is tapped for their heat source. By passing the water through the condenser it has a temperature rise of 50° F. which raises the city's water temperature by 4.5° F. This is a very desirable feature for the home owner because it represents a considerable savings in the fuel which would be required to raise his water temperature by this amount for such things as washing, bathing, cooking, etc. At the same time part of the rejected heat by the condenser may be used for heating the rink's dressing rooms and offices.

WATER TO WATER SYSTEM

Since water is the source of heat it has the same advantages as the water to air type. During the cooling cycle valves 1, 2, 3 and 4 are open and 5, 6, 7 and 8 are closed (see figure 4). The pump circulates water through the conditioner coil where it absorbs heat going to the conditioned space. The water then passes through valve 1 to the evaporator where its temperature is reduced. From the evaporator the cold water passes through valve 2 to the pump and the cycle is repeated. The water source pump circulates water through valve 3 to the condenser where it absorbs the heat of condensation from the refrigerant. From the condenser the well water passes through valve 4 to the drain.

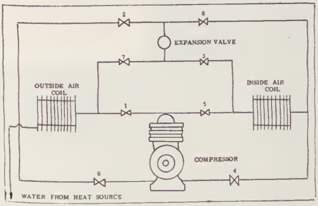


Figure 3—The water to air system

BASIC HEAT PUMP PROBLEMS

There are several basic problems which have kept the heat pump from being utilized as a means of heating and cooling both industrial and residential installations. One of these problems is the heat source.

The desirable characteristics of the heat source are a low initial and operating cost and as high a temperature as possible. With these points in mind let us investigate the available heat sources.

Air as the heat source: Perhaps the most common source of heat for the heat pump is the outside air. This source has the distinct advantage of being "free." At the same time the heat pump manufacturers can produce a completely "packaged" unit.

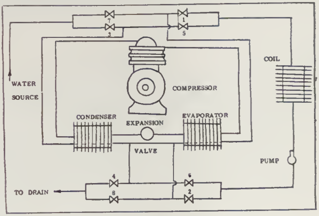


Figure 4—The water to water system

The disadvantages of this system are that the heating demand increases as the air temperature drops and as the temperature falls below 32° F., frost will form on the evaporator coils.

Air temperature variation influences the COP of the heat pump. As the outside temperature drops, the COP is greatly reduced. This logically leads us to the conclusion that the heat pump with air as its source of heat may only be used in regions of relatively mild climate.

Several methods are available for partially offsetting low temperatures. An auxiliary heating element may be employed or a heat storage tank may be used. The storage tank would store heat during mild periods which could be called upon during extreme cold periods. Manufacturers, however, are reluctant to use storage tanks because their size is often out of proportion to the heat pump's size.

Experience with commercial installations in Southern California has shown that the COP for minimum temper-

(Please turn to page 42)

What's doing.

Schlieren photographs, above and left, illus
trate different phases of airflow investigation
Development of inlets, compressors and tur
bines requires many such studies in cascade
test rigs, subsonic or supersonic wind tunnels

■■ at Pratt & Whitney Aircraft in the field of Aerodynamics

Although each successive chapter in the history of aircraft engines has assigned new and greater importance to the problems of aerodynamics, perhaps the most significant developments came with the dawn of the jet age. Today, aerodynamics is one of the primary factors influencing design and performance of an aircraft powerplant. It follows, then, that Pratt & Whitney Aircraft — world's foremost designer and builder of aircraft engines — is as active in the broad field of aerodynamics as any such company *could* be.

Although the work is demanding, by its very nature it offers virtually unlimited opportunity for the aerodynamicist at P & W A. He deals with airflow conditions in the engine inlet, compressor, burner, turbine and afterburner. From both the theoretical and applied viewpoints, he is engrossed in the problems of perfect, viscous and compressible flow. Problems concerning boundary layers, diffusion, transonic flow, shock waves, jet and wake phenomena, airfoil theory, flutter and stall propagation — all must be attacked through profound theoretical and detailed experimental processes. Adding further to the challenge and complexity of these assignments at P & W A is this fact: the engines developed must ultimately perform in varieties of aircraft ranging from supersonic fighters to intercontinental bombers and transports, functioning throughout a wide range of operational conditions for each type. Moreover, since every aircraft is literally designed around a powerplant, the aerodynamicist must continually project his thinking in such a way as to anticipate the timely application of tomorrow's engines to tomorrow's airframes. At his service are one of industry's foremost computing laboratories and the finest experimental facilities.

Aerodynamics, of course, is only one part of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program — with other far-reaching activities in the fields of instrumentation, combustion, materials problems and mechanical design — spells out a gratifying future for many of today's engineering students.

Modern electronic computers accelerate both the analysis and the solution of aerodynamic problems. Some of these problems include studies of airplane performance which permit evaluation of engine-to-airframe applications.

Design of a multi-stage, axial-flow compressor involves some of the most complex problems in the entire field of aerodynamics. The work of aerodynamicists ultimately determines those aspects of blade and total rotor design that are crucial.

Mounting a compressor in a special high-altitude test chamber in P & W A's Willgoos Turbine Laboratory permits study of a variety of performance problems that may be encountered during later development stages.

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OUT OF THE BRIEFCASE

PRE-FLIGHT PHYSICAL

The small but powerful T58 gas turbine engines were given their "preflight physical" in a specially constructed helicopter rotor test stand at General Electric's Flight Test Center before actual flght testing.

The new turboshaft engine has been qualified to power experimental aircraft and is undergoing a successful series of rotor, preflight and flight tests to prove its ability to provide good helicopter performance.

The T58 engine is expected to substantially increase the speed, range and payload of helicopters presently powered by piston engines. It is scheduled to power the Sikorsky HSS and Vertol H-21 helicopters.

The small, p o w e r f u l engine weighs only 325 pounds with reduction gearing but produces over 1,000 hp — a power-to-weight ration nearly three times greater than piston engines now powering helicopters.

GUIDED MISSILE SUBMARINE

Westinghouse, under contract with the Navy, is designing a nuclear propulsion plant for an atomic-powered submarine capable of carrying and firing guided missiles. This will be the first guided missile sub with nuclear power.

This guided missile submarine will utilize a submarine-fleet-reactor-type nuclear propulsion plant which Westinghouse is designing for fleet type submarines authorized in Navy's ship-building program.

A T58 gas turbine engine on the test stand being readied for helicopter installation.

Westinghouse has already supplied the nuclear power plant for the world's first atomic submarine, the Nautilus, and is now working on the first nuclear power plant for a large surface vessel.

CLOSED CIRCUIT TV

A closed circuit television camera is being groomed by General Electric engineers at the Hanford atomic plant for the ticklish task of patrolling the rear face of an atomic reactor.

Designed to move automatically along a monrail near the wall of the reactor, the camera will transmit a picture of reactor components to an operator seated at a console behind thick radiation shielding. Television already has been tried successfully in a Hanford building where the nuclear fuel plutonium is extracted from fissioned uranium, but this test marks the first attempt to use TV at a reactor site.

Use of the camera is expected to speed maintenance jobs by making it possible to pinpoint trouble spots before special work crews are sent into the area. The camera is installed in a protective metal box where its lens peers out through a safety glass window. If moisture collects on the window, an automotive-type window wiper wipes it clear. A floodlight on each side of the camera provides illumination.

Equipped with a pan and tilt mechanism, the TV camera can be turned or 'tilted" simply by moving a switch at the control panel. By combining the features of a vertically-movable monorail with the pan and tilt apparatus, engineers have provided a means of gaining complete camera coverage of the entire face of the reactor.

(Please turn to page 30)

SUPER-HARD CRYSTALS

The time-honored belief that "only diamond scratches diamond" became obsolete when the General Electric Research Lab annouced the discovery of an entirley new material never found in nature.

"Borazon," GE's name for its cubic boron nitride, scratches diamond with ease and remains hard at temperatures where diamond literally burns up. The discovery can have far-reaching impact on industrial processes and thus increase the value of products all of us will use in the future.

It has been proved by research that borazon is in the same general range of hardness as diamond and thus many times harder than the next-ranking materials on the hardness scale. Borazon appears superior to nature's most glamorous substance in one important characteristic. Diamond, being basically carbon, literally burns up in air at about 1600 degrees F, while Borazon can withstand temperatures of more than 3500 degrees F. Borazon's resistance to oxidation will make possible superior methods of mounting stones in industrial tools and also may allow bits and wheels to be operated at higher speeds.

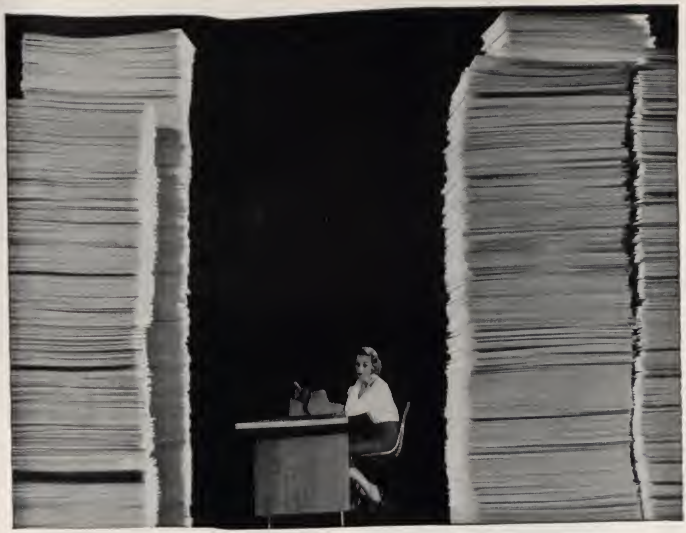
The first Borazon exhibited consisted of tiny crystals no larger than grains of sand, but even in this form is considered suitable for many industrial uses. The material is generally black, brown or dark red, though white, gray and yellow crystals have been made.

Superpressures above 1,000,000 pounds per square inch and temperatures exceeding 3000 degrees F are used to produce crystals of boron nitride with a structure that is not hexagonal (like graphite) but cubic (like diamond).

X-ray diffraction tests of borazon reveal that the alternate atoms of boron and nitrogen are packed together almost as closely as the carbon atoms in diamond. The density is also about the same (specific gravity: 3.45 for borazon, 3.50 to 3.56 for diamond).

The sequence of photographs shows the behavior of diamond and borazon crystals when subjected to intense heat. At temperatures of 2000°F the diamond has almost completely oxidized while the borazon is still intact.

Cuts courtesy of G.E.



CAMPUS NEWS

The Theta Taus of Gamma Beta

THETA TAU

Theta Tau's at George Washington University celebrated the twenty-second anniversary of their chapters founding this spring after the initiation of five new members. Last fall a banquet and ball marked the forty-third birthday of the fraternity after the initiation of seven new brothers.

The social climate of Theta Tau followed its usual course of merry-making and hard work. The traditional shrimp feasts and beer busts were enjoyed by all whetting the brothers' anticipation for the Family Picnic on the first of June.

Theta Tau has provided the only Engineering School representation in the University intramural sports for the past several years, with its athletic program. Theta Tau's rise of over 25% in the overall school standings this year was highlighted by the capture of the table tennis trophy and the near capture of the league softball championship. All of the brothers in Gamma Beta Chapter are extremely proud of "Strikeout" Jim Sullivan, who has demonstrated enough "stuff on the ball" to rate as one of the best pitchers in the leagues.

SIGMA TAU

The past year was a very productive and satisfying one for the members of Xi Chapter of Sigma Tau Fraternity.

In cooperation with a request from the Dean, all of the members and pledges in Sigma Tau took a battery of diagnostic tests. These tests were to provide the necessary criteria, with Sigma Tau as the control group, for evaluating the problems of the probationary students.

The tutoring service of Sigma Tau functioned exceptionally well and proved to be of great service to a great many engineering students. The program received special commendation from the Washington Alumni Association of Sigma Tau and the Dean.

Twenty new members were initiated during this year. This group constituted an exceptionally fine cross-section of prospective engineers. It was the pleasure of Xi Chapter to have the honor of initiating its first lady member, Miss Barbara Seehorn. It was also a pleasure to extend an invitation to Dwight Shytle, a truly accomplished engineer and a sincere friend of Xi Chapter.

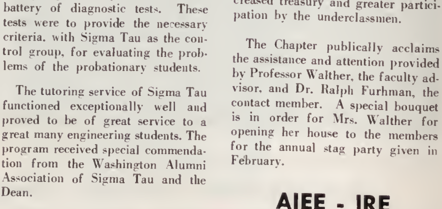
A. S. C. E.

The American Society of Civil Engineers Branch at the George Washington University concluded its year with a well rounded program of meetings, parties, picnics, conferences, and field trips. Progress in the scope of subjects, attendance, and the initiation of social periods after the meetings has resulted in an increased treasury and greater participation by the underclassmen.

The Chapter publically acclaims the assistance and attention provided by Professor Walther, the faculty advisor, and Dr. Ralph Furhman, the contact member. A special bouquet is in order for Mrs. Walther for opening her house to the members for the annual stag party given in February.

AIEE - IRE

The Joint Student Branch of the American Institute of Electrical Engineers — Institute of Radio Engineers is concluding another successful year at the University. The Student Chapter boasts 120 members, making it the largest of the Engineer-



Xi Chapter of Sigma Tau

ing Societies. Over half of the membership enjoys the additional benefits of affiliation with the national organization.

The chapter has brought to the campus many specialists, many of national engineering fame, who have spoken on the earth satellite, high fidelity recording, engineering management, electronic computers, and other pertinent topics.

During the school year, Joe Greblunas and Albert Pinto received awards presented by the AIEE. Similarly, John Manning and Earl Reber won awards from the national and local branches of the IRE.

A. S. M. E.

Since 1924, the American Society of Mechanical Engineers has been providing its members with a well rounded agenda. Not to be outdone this year, every phase of Mechanical Engineering has been highlighted. The traditional showing of the Indianapolis 500 Mile Classic provided a thrilling spectacle appreciated by all.

The annual competition for the John Cannon Award was won by Morrow Moore. His paper on "Liquid Propellant Propulsion Systems" also placed him "in the money" at the Washington area competition.

The chapter is especially indebted to its faculty advisor Professor Cruickshanks, and to Charles Greely for their assistance throughout the year.

Engineers in Journalism Honorary

Dave Lewis and Jim Lear, Associte Editor and Circulation Manager of MECHELECIV, were initiated into Pi Delta Epsilon, honorary Journalism fraternity, on March 30, 1957. The initiation took place in Sutdio A of Lisner Auditorium and the Banquet was held at Aldo's Restaurant.

A.S, M.E.

President .... John Cannon
Vice-President .... Jerry Renton
Secretary .... Gene Wong
Treasurer .... Jack O'Neale
Engineers' Council
Representative .... Bud Ryerson

THETA TAU

Regent .... Ray Sullivan
Vice-Regent .... Vince Rider
Scribe .... Chuck Hunter
Assistant Scribe .... Phil Payne
Treasurer .... Dick Browne
Assistant Treasurer .. Mickey Boothe
Engineers' Council
Representative .... Bob Reining

A.S.C.E.

President .... Dick Haefs
Vice President .... Dave Halsey
Secretary .... Atwood Barwick
Treasurer .... Dick Pronk
Engineers' Council
Representative .... Dave Halsey

A.I.E.E. - I.R.E.

President .... Norm Street
Vice-President .... Chuck Smith
Secretary .... Woodrow Everett
Treasurer .... Bob Keith
Engineers' Council .... Chuck Smith
Frank Narr

SIGMA TAU

President .... Art Wedler
Vice-President .... Norm Street
Secretary .... Fred Hallberg
Treasurer .... Dick Haefs
Engineers' Council
Representative .... Irv Shick

ENGINEERS' COUNCIL

Phil Payne
Vince Rider
Ralph DeLalla
Woodrow Everett
Ray Sullivan
Bruce Taylor

STUDENT COUNCIL REPRESENTATIVE

Claire Chennault

A MODERN MARRIAGE

THE MATING OF RADIO AND TELEPHONY

by Earl Reber
B. E. E. '57

Ever since the invention of the telephone in 1876, construction of the facilities to carry the voice currents from one subscriber to another has been a major problem facing all telephone companies. Continued growth in population has created an ever-increasing demand for telephone service, thus causing an ever-increasing ne d for more and more telephone facilities. Therefore, all telephone companies are faced with the need for continual expansion of their facilities to provide more telephone service.

The magnitude of this problem is better understood if one considers the cost of the least expensive type of outside facility, a two-wire telephone line.

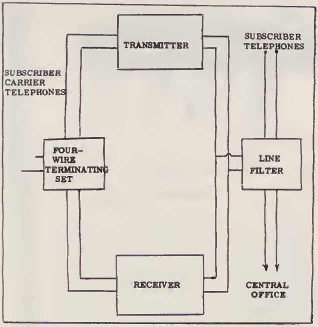


Figure 1—Subscriber Carrier Terminal

An average cost figure, obtained from the Rural Electrification Administration Telephone Program, for a two-wire pole line in reasonably open country is $475 per mile. The cost figure rises very rapidly as the terrain becomes mountainous, heavily wooded, or heavily populated. Such conditions require more labor and material, obviously causing the costs to rise. Placing a pair of open wires with the necessary hardware on an existing pole line costs approximately $140 per mile, provided that the pole line is capable of carrying two additional wires. In many cases, the existing pole line is old and overloaded such that many poles must be replaced, causing the cost figure to rise at a rapid rate. Thus, one can readily see that construction is a costly problem. whether it be new construction or simply additions to existing facilities.

Frequency considerations are also an important factor. An open wire transmission line such as a two-wire telephone line is capable of transmitting a frequency range in excess of 500 kilocycles. For our purposes, a practical frequency range would extend to 450 kilocycles. A telephone conversation requires frequencies from 250 cycles to 2500 cycles, a range of 2250 cycles. This indicates that the telephone transmission lines from the central office to the subscribers are employed to approximately 0.45 per cent of their spectrum capability.

Subscriber carrier systems are one method of reducing costs. Although telephone carrier systems have been employed for many years on trunk facilities to utilize the frequency capabilities of the transmission lines, only in recent years has serious consideration been given to employment of such systems on subscriber lines. The subscriber lines are the lines which form the network from the central office to the subscribers in the exchange area.

Subscriber carrier systems were developed to an economical possibility within the past few years. These systems provide a means of employing the transmission lines from the central office to the subscribers much more effectively. Some systems have as many as ten channels of carriers, thus allowing as many as eleven simultaneous conversations on one pair of wires. In general, the practical limit of the available types on the market today is seven channels.

Seven channels of carrier are a rule of thumb limit since generally three of the available channels will suffer interference from outside sources or from carrier channels on adjacent facilities. Thus, in order to maintain high standards of communication, seven channels of subscriber carrier are usually the limit on a given transmission line.

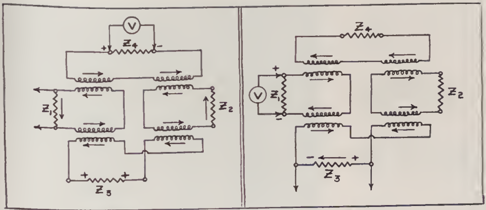


Figure 2a *Figure 2b*

Figure 2
Four Wire Terminating Set
Z_1—Line impedance
Z_2—Line balancing network
Z_3—Transmitter input impedance
Z_4—Receiver output impedance
(a) Signal received
(b) Signal transmitted

Although subscriber carrier systems were developed primarily for rural areas, they are receiving serious consideration for application in metropolitan areas. The demand for such systems is increasing rapidly, indicating that this new field will expand quite rapidly.

A telephone carrier system is basically a means of utilizing a transmission line more effectively, or more efficiently from the point of view of frequency capability. The process employed is referred to as frequency division multiplexing and consists of nothing more than modulating a carrier frequency with voice frequencies and then transmitting the derived frequencies with or without the carrier. This process is simply a method of reallocating voice channels over the frequency spectrum which a transmission line is capable of carrying.

Practical Considerations

A subscriber carrier system must be economical both in initial cost and maintenance to be practical. Within the past few years, systems have been developed to provide ten-party service with full selective ringing at a cost of \$750 to \$1200 per channel. Thus, a channel of subscriber carrier, costing \$1200 or less will in effect provide another transmission line "on top" of an existing line.

Using the average cost of \$140 per mile to place a pair of wires on an existing pole line, one can readily deduce that a subscriber carrier system should be considered if the line under study is ten miles long. As pointed out earlier, the \$140 per mile figure rises rapidly under adverse conditions such that a carrier system may prove economical for much shorter ranges than ten miles.

One system, costing \$1200 per channel, has five available channels. With this system, a ten-party telephone line can supply ten-party service to an additional fifty subscribers at a cost of \$6000. With five carrier channels, the transmission line is capable of carrying six simultaneous conversations such that each of the sixty subscribers would receive equivalent ten-party service.

Fundamental Circuit of a Carrier System

A channel of a subscriber carrier telephone system consists of two terminals connected by a physical circuit. These terminals, one located in the central office and the other at the subscriber end of the line, consist of a radio transmitter, a radio receiver, and associated directional filters. Figure 1 is a block diagram of one carrier terminal. Obviously, the carrier system is simply a radio system in which the radio waves are transmitted over the physical circuit instead of through free space as in a conventional radio system.

The voice frequency signal to be transmitted enters the four-wire terminating set of the terminal of figure 1 from a conventional two-wire telephone line. The four-wire terminating set converts the two-wire telephone line to the four wire system required for two way carrier transmission. The voice frequency signal passes through a low pass filter to the modulator stage of the transmitter.

(Please turn to page 43)

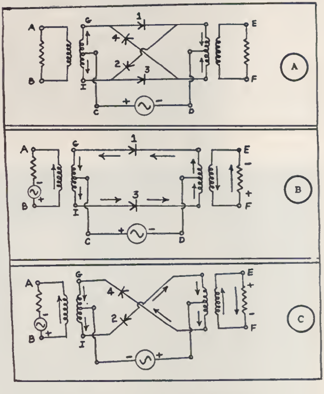


***Figure 3*—Lattice Type Modulator**

A–B Voice input terminals
E–F Modulator Output terminals
(a) Only carrier frequency applied
(b) Carrier and voice frequency applied
(c) Carrier polarity reversed

THE 1957 BANQUET AND BALL

The elegant ball room of the Willard Hotel was a scene of gay activity on the evening of May 4, 1957. when the Engineers of GWU held their annual Banquet and Ball. The annual highlight of the engineers' social season turned out to be one of the best attended in years with over 200 undergraduates, graduate students, alumni and faculty members taking part in the festivities.

The chairman of the 1957 Banquet and Ball Committee, Tony Lane kicked off the activities at the head table. "Deacon" Ames delighted everyone with a surprise visit after his return from South America only several hours hence.

Following the prayer by Professor Cruickshanks. everyone devoted their utmost attention to dispatching the "vittles." ham and yams served in the true Southern fashion.

Following an introduction by Howard Davis, president of the Engineers' Council, Dean Mason regaled the diners with a short after-dinner speech punctuated liberally with humor, but also containing the serious aspects of the Engineering School's growth and proposed expansion.

After Dean Mason's speech Tony Lane assumed the M. C.'s role for the remainder of the evening.

The A. S. C. E. Prize Paper Awards were presented by Dean Walther, faculty advisor of the student chapter. to Dick Rumke. senior, and Dick Haefs, underclassman.

Professor Cruickshanks announced that the A.S.M.E. Prize Paper Award was won by Morrow Moore. Bill Mulkey, the chapter president, was presented with the Headquarters A.S.M.E. Award as the student who had contributed most to the chapter during the past year.

The I.R.E. contest winners, John Manning and Earl Reber, who were the high-scorers in a test given by the District of Columbia Chapter of the I.R.E., were introduced by Professor Hanrahan. Professor Hanrahan also introduced Albert Pinto and Joe Greblunas who received awards from the A.I.E.E. Joe Greblunas was named as the member who had contributed outstanding service to the A.I.E.E. Chapter.

John Manning, president of the joint branch of the A.I.E.E.-I.R.E. presented a gift to Professor Hanrahan in recognition of his assistance to the organization.

"Deacon" Ames delighted the Crenças with stories of his trip to Ceylon and South America.

Tony Lane, proclaimed as the outstanding senior, holds the coveted Theta Tau Award Plaque. Tony's activities include several terms on the Engineers' Council; serving once as vice-president; the Student Council; Theta Tau, where he served as vice-regent; the joint student branch of the A.I.E.E.-I.R.E.; and MECHELECIV.

In addition to these other duties, Tony has found time to serve as Student Assistant for the E.E. department.

As chairman of the Ball and Banquet committee of the Engineers' Council, Tony was in no small way responsible for the success of this year's shindig.

Unlike most of the seniors, who hope to emit a sigh of relief and abandon books forever after, Tony is making plans to attend Law School next year and hopes to add an L.L.B. to his title.

The Sigma Tau Freshman Award was presented to Henry Beck by Sigma Tau president, Art Wedler. Henry merited the award by accruing the highest Quality Point Index in his Freshman Class.

The Theta Tau Outstanding Senior Award was presented by Dean Mason. Following a suspense highlighted introduction, Tony Lane was announced as the recipient.

The Mecheleciv and Engineers' Council Keys were awarded in phantom fashion, since the real items were still somewhere en route from the jeweler's.

The Engineers' Council keys were awarded to Dick Rumke, Jerry Renton, Vince Rider, Mickey Boothe, Warren Crockett, Claire Chennault, Dick Pronk, Bill Grady, Dan Palmasani, Albert Pinto, Jim Somervell, and Norm Street.

Mecheleciv Keys were announced for Roy Brooks, John Manning, Dick Rumke, Norm Street, Sy Matthews, Tony Lane, Jim Lear, and Dave Lewis.

Maintaining a two-year tradition, Dean Mason presented the retiring president of the Engineers' Council, Howard Davis, with a gavel. Soon after, Ray Sullivan, the new Regent of Theta Tau presented a similar gavel to Earl Reber, who had served as Regent for the past year. Irv Shick, past president of Sigma Tau was presented with a gavel by Art Wedler the present chapter president.

Music for the evening, provided by Joe Maguire's Boys, ran the gamut from throbbing Latin rythms to rousing polkas. For the few who were a little slower on their feet, a number of sentimental tunes were provided at a slower tempo. Operating on the old theory of making everybody happy, Joe Maguire provided an array of vocal talent to please those who like to just sit and listen.

The ball broke up at midnight officially — and one o'clock unofficially. Not being the type to discourage easily, most of the engineers carried on the festivities at private homes with the remainder converging on the Hot Shoppes and Howard Johnson's around the city.

SENIORS LAUD CRUICKSHANKS

Professor Benjamin Carpenter Cruickshanks was feted by a group of the 1957 Senior Class on May 17, 1957. A dinner was held in his honor in the Market Room of Cannon's Steak House.

Professor Cruickshanks was cited by the thirty-odd attending Seniors for his interest in student affairs, (Professor Cruickshanks is the faculty advisor of Theta Tau, Sigma Tau, A.S.M.E., MECHELECIV, and the Engineers' Council) and his unselfish assistance to the students of the School of Engineering.

Professor Cruickshanks was presented with a Life-Time desk pen bearing an engraved plaque. The inscription reads "To Professor Cruickshanks, from the '57 Senior Class."

ALUMVIEWS

PRESIDENT'S MESSAGE

By Frank T. Mitchell
President, Engineer Alumni Asso.

The Engineer Alumni Association will conclude its schedule of activities by holding its Annual Reception on Tuesday, May 28, from 5:00 to 7:00 p.m. in the Burlington Hotel. Guests of honor will be members of the Senior Class and the faculty of the School of Engineering. The reception will also serve as a victory rally for the workers of the 1957 Alumni Fund in behalf of the Tompkins Hall Equipment Drive.

Tickets for the reception will be $2.00 per person and they may be purchased at the door. You will want to see your classmates, old and new professors, and the graduates of 1957, so mark this date on your calendar now: Tuesday, May 28, 5-7 p.m., in the Burlington Hotel.

In the notice announcing the Annual Reception, Engineer Alumni Association members will find their ballots for the officers for the 1957-58 year. The ballots should be filled out promptly and returned to the Association in care of the University.

In this final President's Message of the year, may I take this opportunity to thank all of those whose hard work and many hours of devotion have contributed to the success of the Association's program. I think many strides have been taken by our alumni in behalf of their Alma Mater during the past year and I believe we can look forward to continued good fellowship and service.

ALUMNI NOTES

J. P. Hewlett (B.S. '42) has joined the Plant Operations Department of Archer-Daniels-Midland Company as a process engineer. Mr. Hewlett came to A. D. M. from Denison, Texas, where he was manager of Sharon Research Co., Division of Safeway Stores. He has also worked for the Humko Co., Memphis, Tennessee, as the head of chemical and engineering research, and was employed as a chemist for the Bureau of Standards in Washington, D. C.

Briscoe Gray (B. S. E. '27, LL.B. and M. P. L.) after serving with the Engineer Corps during the war operated the Gray Brick and Tile Company in Bowie, Maryland. After selling this plant, he joined the Miller Equipment Company and has worked with them since as a field construction superintendent. Mr. Gray has recently written an article for the Brick and Clay Record on the maximum production of brick.

Joseph E. Gray (B.S. in C.E. '27 and C.E. '37) succeeded A. T. Goldbeck as Engineering Director of the National Crushed Stone Association, Washington, D. C. He has been associated with NCSA since the formation of its research laboratories in 1928. He worked as testing engineer in charge of investigations on the uses of crushed stone. Also, Mr. Gray was employed by the National Bureau of Standards and the Bureau of Public Roads.

Jack Brandau (B.M.E. '56, Sigma Tau, A.S.M.E.) is presently employed at the Newport News (Virginia) Shipbuilding Co. Jack and his wife, Ann have increased their family by a new son as well as an adopted puppy.

SATELLITE

(Continued from page 13)

than that expected may reduce the capabilities in a non-crucial way, but only a slender margin of performance separates the propulsion system which sends the satellite two-thirds of a revolution around the earth from one which sends it 1,000 revolutions.

A 20-inch sphere will probably be used for the first attempt. The payload will weigh 21½ lbs. with half given to the shell, brackets, other structural materials in the shell, and the attachment to the third stage rocket. The rest — about 10 lbs — will be given to the radio tracking device, telemetering equipment, antennas, and instrumentation. The shell will be an alloy of 96 per cent magnesium, three per cent aluminum, and one per cent zinc. It will be formed in the shape of two hemispheres and have a wall thickness of 0.050 of an inch. A "hat band" of metal will be welded over a concave circumferential depression to provide a pressure chamber of 15 psi, permitting relative measurements of outer space pressures. Once welded, surfaces are polished to a four microinch finish and then gold plated to insure maximum reflectivity. Watchmaker screws secure the hemispherical skins to the bracing and to one another.

MEASUREMENTS

Optical Tracking

When conditions are right, the satellite will be visible against a twilight sky, as a very faint and fast moving star — about as dim as the faintest star a human eye can see. If the orbit could be determined accurately, the satellite would be a valuable research tool, even without instruments.

Primary optical observations will be conducted from 12 specially equipped stations. Each will have a 20-inch Schmidt sky camera, capable of registering the image of a 15-inch sphere at 1,000 miles and a three-foot sphere at a distance from the earth to the moon. A series of exposures will be taken of each passage of the satellite on a strip of film. On these pictures, the satellite can be located within two minutes of arc in the sky and within a millisecond in time. Such precision will make it possible to locate observation stations relative to one another and relative to the center of the earth to an accuracy of 30 to 50 feet. This will help to establish the shape of the earth with greater accuracy. Earth-crust structure can be determined by observing the perturbations of the orbit. The rate of spiraling caused by atmospheric drag will provide accurate measurements of air density.

Radio Detection

If the satellite is not sighted the first time around, the possibility of sighting it will assume constantly greater uncertainty. Thus, radio detection is a must.

A radio beacon and storage batteries, weighing one pound, will provide several weeks of life. The output signals can be used to report the observations as well as satellite location. To pick up the signals, a line of tracking stations will be located along the 75th meridian from Washington, D.C. to Santiago, Chile. A line was provided as a practical matter, to avoid a large number of stations throughout the world. After every revolution, the satellite will cross this picket line of receivers and transmit the data obtained during that particular period of revolution. This requires the storage of instrument observations by a memory device, which will then be triggered by radio command to release the data as it crosses over the receiver line. Present plans call for a magnetic tape to store the data.

Instrumentation

Each satellite will be a specialized instrument, designed for one or a few specific experiments. The following miniaturized experiments have been devised:

1. A pressure gage to determine if meteorites puncture the satellite's skin. This bellows actuated potentiometer has a range of plus to minus 15 psi, is one inch long, one inch in diameter, and weighs one and one-half ounces.
2. An erosion gage to measure erosion by dust and micrometeorites. A metal ribbon evaporated on glass is mounted on the outside of the satellite skin. As the coating wears away, its resistance increases.
3. A collision microphone to record the number and momentum of micrometeorites which strike the satellite shell.
4. A photocell to measure the earth's cloud cover.

FUTURE SATELLITES

This first satellite—like the other 11 the United States will launch during an 18 month period—will be relatively simple. In later years, when better suited materials and techniques are found, more complicated satellites will be built.

The future satellites will have higher orbits and use television cameras to scan the earth for military, weather, and geodetic data. They could conceivably carry astronomical telescopes and radio data back to earth by solar batteries.

TIDE

(Continued from page 15)

tion. Controversies between power companies and the State of Maine ended with the State of Maine refusing to provide legal machinery for the distribution of power, and the project collapsed.

Problems in the Two-Basin System

During the winter months, there is little or no ice formed in a tidal river or bay because of the constant movement of the tides. But if a dam were to be placed across a tidal river, as is the scheme in the basin system, the water would not reach spring and neap levels twice a day; thus, ice would be formed and the up-and-down motion of the ice, as the plant is in operation, would prove to be a problem. The design of the dam would have to have special consideration, so that the ice on one side pressing against it and the sea water on the other would not be injurious to the dam. A rock-filled dam seems to be the most reliable under the circumstances. Special gates would have to be placed in front of the intake turbines, so that no large ice blocks are allowed to flow into the turbines causing damage to the turbine blades.

With the moving of a tidal river or bay, tons of sand, rock, and mud move along with the tidal current out to sea. When a dam is placed in a tidal river or bay, the sand, dock and mud will settle at the bottom of the basin; this accumulation of silt will, in years, decrease the water storage capacity of the basin and decrease the power output of the plant. Dredging units would have to be permanently located at various points in the basin. The silt would have to be moved up stream by boat to some disposable point.

Special consideration must be given to the matter of deterioration of metal parts permanently or periodically submerged in sea water. Turbine blades, turbine ducts, and other parts permanently submerged in sea water must be made of a noncorrosive material. Special alloys of nickel and stainless steel, which are noncorrosive, have been suggested for the permanently submerged parts. Metal parts periodically submerged in sea water, such as gates, locks, and racks offer no particular difficulties. The systematic testing program carried out over a number of years by various interested agencies has proved that cheap and reliable protection from corrosion may be obtained by the careful and regular application of anti-fouling or other suitable paints.

Now for the last and most important problem, which is subnormal neap tides, in the tidal hydro-electric system. Subnormal neap tides occur about 15 per cent of the time the plant is in operation. These subnormal neap tides cause a reduction in power output, sometimes as much as 35 per cent. In the design of a tidal hydro-electric plant, consideration must be given to whether the plant is going to operate at maximum firm power or maximum peak power. (A plant not operating at its full capacity produces constant firm power, and subnormal neap tides do not vary its output. A plant operating at its full capacity is producing maximum peak power, and it is affected by subnormal neap tides). If a plant operates at maximum firm power output, there is no problem. But if the plant is designed to produce peak power continuously, subnormal neap tides cause a variation in output.

Suppose a plant were to operate under the condition of peak power; subnormal neap tides would cause a 35 per cent drop in output, while the demand was still 100 per cent. Consumption of electricity would be cut at this period of subnormal neap tide, and consumers would not get the electrical energy needed to carry on their business. There have been two schemes considered to offset this problem. A fresh water reservoir can be made to empty into the high-level basin at these subnormal neap tides; the only fault of this scheme is that fresh water is not always available at the place considered for a tidal power station. The more practical scheme is a steam turbine plant situated on the tidal dam to supply power at subnormal neap tides.

Cost Analysis

The economic value of any form of power depends necessarily upon the cost of competitive types of power. At the present time, steam, which utilizes coal or other fuel for its operation, is competitive with any other type of power scheme. It is required, therefore, to examine the cost of steam power and to compare its cost with that of tidal power.

Consider the cost of a steam turbine plant operating at the same peak continuous output as that of a tidal hydro-electric plant.

The capital cost of a steam turbine plant which is rated at 270,000 horsepower is estimated at thirty-five million dollars.

The annual cost of operating a modern steam plant, to provide the same services for the combined hydro-electric and peak-load steam plant, is $7,440,000.

This amount of $7,440,000 represents a total cost of supplying the load demand at a maximum rate of 270,000 horsepower; therefore, the cost per horsepower per year would be about $27.55.

Now, consider the cost of a tidal hydro-electric power plant operating at 270,000 horsepower with peak load-steam.

The capital cost which includes such major items as, rock filled dams both high and low level basin, gates, and turbines, machinery (hydraulic and electrical), power house structure and substructure, and dredging, is estimated at $177,668,000.

The annual cost is $18,784,000 which represents interest, sinking fund, depreciation, contingency reserve, maintenance and repairs, and operations. Hence the cost per horsepower per year is about $69.57, as compared to $27.55 for steam.

The economic value of any form of power depends upon the cost of competitive power for the same output. Steam turbines are competitive to any form of power. A cost analysis shows that the capital cost of tidal power is about five times that of steam, and the annual cost of tidal power is about two and a half times that of steam.

There are tremendous deposits of coal in the world. Until the time when the natural resources of coal and now atomic energy are exhausted, steam will play the leading role in the generation of electrical energy.

Therefore, although the tides possess tremendous energy, the harnessing of tide energy as hydro-electric power is not economically feasible at the present time.

CREATIVE ENGINEERING

(Continued from page 23)

The emotional blocks are by far the largest grouping, and they include all our fears, and most of the defense mechanisms that we build up in order to make our lives better. They are such as fear of making a mistake or making a fool of oneself, over-motivation to succeed quickly, lack of drive in carrying a problem through to completion and test, refusal to detour in reaching a goal, and a too-great desire for security (no desire to pioneer).

Any increase in selfunderstanding, in realizing that there are blocks and inhibitions, will aid the creative process.

There are useful creative techniques which when applied carefully and repeatedly will awaken and strengthen the creative potential.

An effective and easy way of developing the questioning habit is to use check lists. One such list is Alex F. Osborn's "Check List for New Ideas." It includes such items as:

Put to other uses?
Adapt — copy, does past offer a parallel?
Modify — stronger? higher? longer? thicker?
Minify — smaller? condensed? shorter? lowwer? lighter?
Substitute — what else instead? other material? other process? other power?
Rearrange — other layout? other sequence?
Reverse — transpose positive and negative? turn upside down?
Combine — an alloy? combine purposes?

There are many other forms of check lists. One of most simple is: Question, Observe, Associate, and Predict.

Another technique for arriving at solutions is "attribute listing." As an example, take the old wooden-handle screw driver of a few years back. These are the attributes of the parts of the driver: (1) round, steel shank; (2) wooden handle riveted to it; (3) wedge-shaped end for engaging screw slot; (4) manually operated; (5) torque produced by twisting action. Now each of these attributes has been changed many times, each resulting in a new and better screw driver. The round shank became a hex so that a wrench could be applied. The wooden handle became plastic to prevent breakage and electrical shock. Pneumatic and electric power have been substituted for manual power.

Experiments with this technique of attribute listing have shown that the more familiar a group is with certain products, the less easily it agrees as to basic attributes. For instance, a group at AC Sparkplug had no difficulty listing the attributes of a hammer or bicycle but could not agree on the basic attributes of a sparkplug. This points up the danger of familiarity which places things in the category of obvious so they are no longer questioned or observed.

One of the most publicized techniques for obtaining ideas is that of "brainstorming." Brainstorming is a word to describe an activity (usually by groups) by which free association is used to generate ideas. Each member of the group tries to think up as many ideas, however wild or fantastic, as he can; these ideas inspire the other members, and the production multiplies. The "rules" for brainstorming are: (1) no evaluation of any kind is allowed; (2) all are encouraged to think of as wild ideas as possible; (3) quantity of ideas is encouraged; (4) everyone is encouraged to build upon or modify the ideas of the others. This technique is good for the generation of ideas, especially for new methods; another session must be held to evaluate and eliminate. The process is to withhold all judgment until after the ideas are recorded, then to narrow down the list.

In order to be creative, mastery in use of the process is more important than the type of problems to be worked on. A summary of creative steps could be: recognize, define, search for methods, evaluate, select, and test. Look at problems generically — take the broad view. Think big. Get a good balance between analysis, synthesis, and evaluation. Beware of blocks. Practice.

This would appear to have more chance of success than Professor Wendell Johnson's formula for becoming a genius:

How To Be a Genius

1. Find one
2. Follow him around
3. Observe him
4. Do what he does (this may be awkward at first)

HONOR LIST

The Faculty of the School of Engineering has provided for the recognition of meritorious scholastic achievement by the publication of an Honors List.

The requirements for the Honors List are:

(a) The candidate's cumulative quality-point-index is equal to or exceeds 3.00.
(b) At least 30 semester hours credit has been earned as a degree candidate in the School of Engineering.
(c) At least 15 (part-time student) or 30 (full-time student) semester hours credit in an engineering degree curriculum have been earned the immediate two consecutive semesters.
(d) No grade below "C" has been received during the qualifying period stated in (c) above.
(e) No disciplinary action has been taken in respect to the student.

HONORS LIST

Fall Semester 1956

Beck, Henry D.
Browne, Richard A.
Carlson, Herbert D.
Clemons, Ormond L.
Davis, Wayne A.
Dreyfus, Daniel A.
Hall, Stanley R.
Hinshelwood, George D.
Joyce, John D.
Kaminetzky, Jerry
Kee, Orron E.
Keene, Warren E.
Kenyon, Randall C.
Kransdorf, Ronald J.
McChesney, Donald W.
Martin, Robert G.
Milne, J. Scott
Moore, Morrow H.
Perschy, James A.
Renton, Gerald W.
Rogers, George J.
Sapardiman, Soesano
Schuler, Bernard C.
Street, Norman H.
Thau, Stephen A.
Yorkdale, Paul H.

HEAT PUMP

(Continued from page 25)

ature conditions is between 3 and 4 while the average COP for the heating season ranges between 5 and 6.

Water as the heat source: Water would be an ideal source of heat if it could be obtained at a low cost and be chemically satisfactory. Well water maintains essentially the same temperature during all seasons regardless of the outside air temperature changes. For this reason the heat pump will be able to take care of seasonal temperature changes with a constant COP.

It's most important disadvantages are locating an adequate source of water and disposal of the water after the heat has been extracted. The most feasible system would be to have several wells, some for the water intake, and the others for replacing the water so that it could be re-used. This would be a costly initial investment and would require additional maintenance to the wells and well pumps.

An afterthought would also be whether the heat removed from the water during the heating cycle could be replaced during the summer cooling cycle.

Ground as the heat source: Very little information is available on the conduction of heat to and from the soil. Factual information is needed to determine the heat transfer coefficients of various types of soil.

It should also be noted that soil conditions will not only vary throughout the country but conditions in the same locality may not be the same. As an example, the soil in one particular location may be readily adaptable to a dry well installation while only a short distance away the ground may be extremely rocky making a dry well or system of underground pipes uneconomical. However the ground as the source of heat has the same desirable feature as the water, a constant year around temperature. Corrosion and maintenance are other factors which must be given careful consideration when using the ground as the heat source.

DEFROSTING

For the highest operating COP it is necessary that the outside coils (evaporator) be free of frost and ice at all times. In climates where the outside air temperature falls below 32° F., this is a serious problem. Several methods are available for defrosting which include:

1. Reversing the cycle
2. Water sprays
3. Absorbents
4. Electrical heating elements
5. Vents from the inside coil

Reversing the cycle: This method has the disadvantage of removing the heat from the heated space to perform the necessary defrosting. This disadvantage may be overcome if the defrosting cycle is timed to occur during the night or when the heated space is unoccupied. The Westinghouse Heat Pump employs this method and the defrost period has a duration of 3 to 5 minutes.

Water sprays: If an ample supply of water at a temperature above 50° F. is available, then this method may be highly desirable. During the defrosting cycle the water is sprayed with sufficient velocity and quantities to remove the ice. If this system is used it is necessary to have an air coil which is non-corrosive, otherwise additional expense and maintenance would be required.

Absorbents: In an absorbent system some material such as silica gel or calcium chloride is placed in front of the air coil. This removes the moisture from the air before it comes into contact with the coil thus eliminating frost accumulation. This method would be expensive to install because a source of heat must be supplied to remove the moisture from the absorbents.

Electrical heating elements: Many commercial refrigerating plants use electric heating elements to obtain defrosting. The elements are wrapped around the evaporator coils or in some cases the coils are used as the conductors. This system has the disadvantage of requiring a long period to accomplish complete removal of the frost unless excessive current is used.

Vents from the inside coil: Although this method has never been proposed, it has interesting possibilities. If part of the heated air from the inside coil were redirected at specified intervals past the outside coil, defrosting could be accomplished very economically. Only a small portion of conditioned air would be necessary and the occupants' comfort would not be sacrificed.

CONCLUSION

The heat pump's future depends on a variety of variables. The most important are nature and cost of electrical power, the public desire for residential cooling, and the development and utilization of adequate heat sources.

Inexpensive electrical power will place the heat pump on a competitive basis with heating units which employ combustible fuels. It is interesting to speculate that nuclear power may possibly give us this inexpensive electrical energy.

The fact that home owners spend more time at home because of shorter working hours, television and other household luxuries, has caused demand for summer cooling to increase. The heat pump is admirably suited for this purpose, especially in new homes, because of the advantage of a single unit installation. With this fact in mind builders can design the modern home with no chimneys and air tight windows which would never have to be opened. With these changes there would be as much as a 25 per cent savings in heat which would be reflected in much lower operating costs.

Although the heat source is basic in nature, by proper selection of one of the heat sources or by a combination of sources, practically any condition can be met. Published data on soil, temperature, and water conditions throughout the country will be of extreme importance to the engineer in the selection of the proper heat source. This information is now available to a limited extent but complete and comprehensive data is sorely needed. New methods of heat storage for use during cold periods of short duration will help to lift the burden of the heat source by balancing the demands placed on it.

Even in view of the obstacles that confront the heat pump, it is the writer's belief that the heat pump has a bright future as a means of mass comfort rather than a system adaptable to unique situations.

TELEPHONE

(Continued from page 35)

In the modulator stage, the voice frequencies are mixed with the oscillator or carrier frequency. This produces the usual sum and difference frequencies, commonly called the upper and lower sidebands, while the carrier is suppressed in the modulator.

Both upper and lower sideband frequencies are amplified. Since either sideband contains the desired intelligence, only one sideband need be transmitted. The desired sideband passes through the band pass filter, through the line filter to the physical line while the undesired sideband is rejected or alternated by the band pass filter.

As an example, consider a band of frequencies from 250 to 2500 cycles entering the terminal at the four-wire terminating set from the subscriber telephone. This band of frequencies passes through the low pass filter without severe attenuation. Any harmonics above 3 kilocycles are attenuated in the filter. Suppose that the oscillator frequency is 20 kilocycles. The modulator output will consist of two sidebands, a lower sideband of frequencies from 17.500 to 19.750 cycles and an upper sideband from 20.250 to 22.500 cycles. The band pass filter will pass only the desired band, which we will assume is the upper sideband. Thus, the upper sideband containing the voice frequency intelligence is transmitted on the physical circuit.

At the central office terminal similar to that of figure 1, the band of frequencies pass through the received band pass filter, to the demodulator. Continuing with our numerical example, this receiving band pass filter is the only receiving filter in the entire system which will pass the frequency band from 20.250 to 22.500 cycles. This is true even if there are ten carrier channels, with the required twenty receivers on this physical circuit. Essentially, the receiving band pass filter is "tuned" to the particular band of frequencies that are transmitted by the associated transmitter at the other end of the line.

The sideband of frequencies passes from the band pass filter to the demodulator where it is modulated with the receiver oscillator frequency. This receiver oscillator must oscillate at the same frequency as the associated transmitter oscillator. In the numerical example the receiver oscillator produces a 20 kilocycle frequency. The resulting sideband frequencies produced in the demodulator range from 250 to 2250 cycles and from 40.250 to 42.500 cycles. The low pass filter following the demodulator will reject the upper sideband and pass the lower sideband which is the same as the original intelligence transmitted by the carrier telephone.

The lower sideband or voice frequency signal is then amplified, passed through the four-wire terminating set, through the central office switching equipment, out over the called subscriber's line to the subscriber telephone. The voice frequency currents are converted to sound waves by the called party's telephone receiver.

The called party transmits intelligence back to the calling party in much the same manner. The major difference being that the central office transmitter and the calling party receiver oscillator operate at a different frequency and the associated filters are "tuned" to receive or pass the desired band of frequencies.

With careful consideration, one can see that for a ten channel carrier system on a physical line, there are twenty transmitters with associated receivers at the opposite end of the physical line since each channel requires two transmitters with associated receivers.

Four-Wire Terminating Set

The purpose of a four-wire terminating set is to convert the four-wire carrier equipment termination to the conventional two wire telephone circuit. This conversion is necessary to prevent the carrier transmitter and receiver from interfering with one another. Since the transmitter and receiver constitute two one-way communication paths which must be coupled to the same pair of wires, it is obvious that direct coupling would cause the units to interfere. The four wire terminating set is a method of coupling both units to the same lines without interference.

The diagram of figure 2-a represents the four wire terminating set under receiving conditions. The voltage V represents the voice frequency output from the carrier receiver. The coils are wound such that the polarity of V causes voltages across the various coils as indicated. From the diagram, it is obvious that equal currents are set up in the telephone line, Z_1, and the balancing network, Z_2, while no current flows in the input impedance of the carrier transmitter, Z_3. Thus, if the four wire terminating set is perfectly balanced, none of the receiver output signal will enter the transmitter.

The diagram of figure 2-b represents the four wire terminating set under transmitting conditions. The voltage V represents the voice frequency input from the telephone line. The indicated polarity of V causes the indicated voltages across the coils. At this time, it is apparent that no current is set up in the balancing network, Z_2, while currents are set up in the carrier transmitter input impedance, Z_3, and in the carrier receiver output impedance, Z_4. Since the carrier receiver is a one-way path of transmission, the current in Z_4 is of no interest. The signal voltage developed across Z_3 is filtered, modulated and then transmitted by the carrier transmitter.

(Please turn to page 44)

(Continued from page 43)

Thus, the four wire teminating set prevents receiver output from entering the transmitter input terminals while effectively coupling both the transmitter and receiver of the carrier terminal to the telephone line.

Filters

Low pass filters serve two essential purposes in carrier systems. First, since the cutoff point of the low pass filter is approximately 3000 cycles, the frequencies which the subscriber on the physical circuit can put on the line are restricted to below 3000 cycles. Frequencies above 3000 cycles resulting from harmonics created within the telephone or from other sources on the physical circuit beyond the carrier terminals are prevented from disturbing the operation of the carrier circuits. Secondly, carrier frequencies are prevented from passing into telephone sets connected on the physical circuit. This prevents undue attenuation of the carrier frequencies by equipment bridged across the physical circuit beyond the carrier terminals.

High pass filters, incorporated in line filters, pass frequencies above 3000 cycles. These filters are used to pass the carrier frequencies to and from the physical line. The main purpose of the high pass filter is to prevent the carrier equipment from injecting spurious frequencies below 3000 cycles into the physical circuit.

A line filter is a combination of a low pass and a high pass filter, employed to separate normal voice frequencies on the physical circuit from the carrier equipment.

Band pass filters are employed to pass a desired band of frequencies while providing high attenuation to all frequencies outside the pass band. These filters serve as sideband selection filters and as directional filters to separate the transmitted intelligence from the received intelligence in a given carrier terminal. They also serve, to "tune" a receiver to its associated transmitter in that the filter rejects all frequencies outside of its pass band.

Oscillators

Each channel of carrier requires two frequency bands, one for transmission and another for reception. Therefore, four oscillators are required for transmission of intelligence between two subscribers, a transmitter oscillator and a receiver oscillator in each carrier terminal.

Signalling such as dial tone, dial pulses, busy tone, and ringing are accomplished by low frequency tones which are transmitted and received in the same manner as voice frequencies.

Since subscriber carrier systems are much less critical than trunk carrier systems, vacuum tube oscillators with an L-C tank circuit are generally employed to generate the required frequencies.

Suppressed Carrier Modulator

The arrangement of varistor units or germanium-crystal diodes as shown in figure 3 is known as a lattice-type modulator. This arrangement of rectifying units is used both for modulation and demodulation in single sideband, suppressed carrier systems.

The lattice-type modulator combines the voice and carrier frequencies in such a manner that the output con-

(Please turn to page 46)

(Continued from page 44)

tains the upper and lower sidebands, but not the carrier frequency. The process by which this phenomenon is accomplished is known as carrier controlled switching.

If a carrier frequency is applied across terminals C and D, at the instant when terminal C is positive, rectifier units 1 and 3 act as short circuits while 2 and 4 act as open circuits. At any instant when the oscillator polarity is reversed, rectifier units 2 and 4 act as short circuits while 1 and 3 act as open circuits. In either case, one can see that the current from the oscillator divides equally into two currents which flow in opposite directions through the halves of the center-tapped windings such that the resultant output voltage across terminals E and F is zero. Therefore, with no signal across terminals A and B, there is no output across terminals E and F.

In effect, the carrier "switches" the circuit by causing rectifier units 1 and 3 to conduct for half a cycle and then, units 2 and 4 for the other half cycle of the oscillator output. This effect is better demonstrated in figure 3-b and 3-c by the absence of the idle units during the respective half cycle of carrier frequency.

When a voice frequency signal of a smaller amplitude than the carrier is impressed across terminals A and B with the polarity as shown in figures 3-b and 3-c, a voice frequency voltage will be induced across terminals G and I as indicated. Figure 3-b indicates the voice frequency current and the resulting output across terminals E and F when terminal C of the oscillator is positive. When the oscillator polarity reverses, the resulting effective circuit is shown in figure 3-c with the direction of the voice current indicated by the arrows. Thus, one can see that as the carrier reverses polarity, the output voltage also reverses polarity.

The resultant output wave of a lattice type modulator is shown in figure 4. The carrier and voice frequencies are suppressed such that the output contains essentially only the upper and lower side bands.

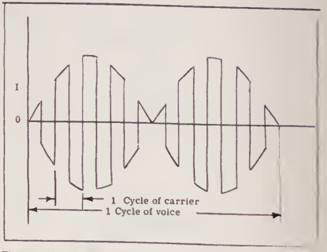


Figure 4—Current waveform of lattice-type modulator.

The principles involved in carrier telephony are such that a carrier system may be considered to be a closed circuit radio system. Essentially, the only difference between a carrier system and an ordinary radio system is that the carrier employs a transmission line instead of free space as a conducting medium.

Subscriber carrier telephone systems were developed to utilize the frequency capability of subscriber lines more effectively. At present, a maximum of eleven simultaneous conversations can be transmitted over one two-wire subscriber line employing ten channels of sub-subscriber carrier. The carrier channels do not disturb the operation of the physical line, but, in effect, create telephone circuits on "top" of the physical line.

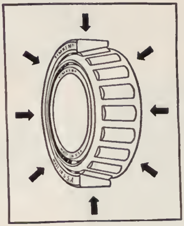
Subscriber carrier systems have reduced the burden of line construction for telephone companies, especially in rural areas, by providing a means of economically employing existing facilities much more effectively.

An Eastern potentate, the Shaw of Hushpoor, had a son who was afflicted with strange seizures. The little son, (his royal title was Shan—rhymes with fan) was in such a bad way that he had to be constantly watched by a governess. One day while the governess was preoccupied, the Shan slipped away and playfully went for a dip in the lotus pool. While the Shan was in the deepest part of the pool, one of his seizures struck him and he promptly drowned. The Shaw was horrified when he discovered what had happened and he immediately called the governess to his side. When she arrived he began to wave his sword in a frenzy and yelled, "Where in Allah's name were you when the fit hit the Shan?"

Tear out this page for **YOUR BEARING NOTEBOOK...**

How to keep the world's biggest mouth chewing

This gigantic power shovel bites off 90 tons, lifts it ten stories, and moves it 290 feet. The engineers who designed the shovel had to provide for the tremendous loads, from all directions, placed on the hoist sheaves and swing machinery. To take the combination radial and thrust loads, keep wheels and shafts turning smoothly under punishing operating conditions, the engineers specified 34 Timken® bearings at all critical points.



Tapered design lets Timken® bearings take both radial and thrust loads

Some bearings can take loads from the sides—some from above. Because of their tapered design, Timken bearings take *both* radial and thrust loads or any combination. And because the load is carried along a full line of contact between rollers and races, Timken bearings have extra load-carrying capacity.

Want to learn more about bearings or job opportunities?

Some of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "Career Opportunities at the Timken Company". The Timken Roller Bearing Company, Canton 6, Ohio.

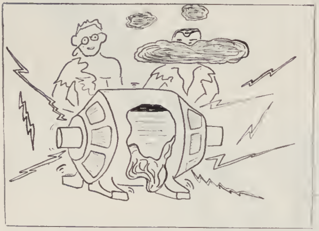
TIMKEN *TAPERED ROLLER BEARINGS*

NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

IT HAPPENED THIS WAY

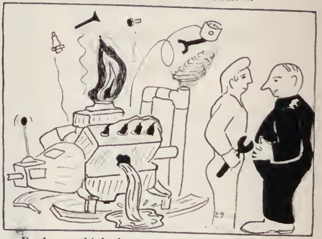
IN OUR LABS

ELECTRICAL ENGINEERING



Joe, I think we must be above the rated load.

MECHANICAL ENGINEERING

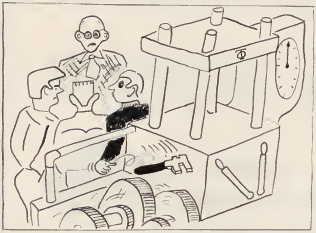


Don't you think the mixture is a little too rich?

CHEMISTRY

Really boys, I'm glad you're interested, but try to stay with the class.

CIVIL ENGINEERING



I'm sure none of you would mind staying a few hours extra to finish this experiment.

ELECTRONICS

Professor would you check my scope? I'm getting interference.

SLICK CHICK-SICK PIC

Joanne's T-V wasn't working properly so she decided to fix it all by herself.

This is how she did it.

1
Adjusted set and aligned chassis.
<——

2
Sized up tools.
——>

3
Selected tools and removed rear cover.
<——

4
Astounded by all of those tubes, she called repairman.
——>

The wonders of electronics never cease to amaze us. Being displayed in this sequence is one of the nicest sets ever to grace a vertical chassis. Although the design is basically conventional, refinements have provided exceptional response with no sacrifice in quality.

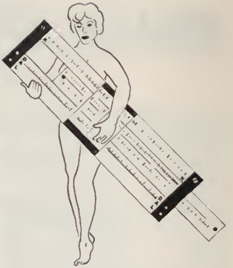
Those of you who are primarily interested in the technical aspects will be surprised at the size of the picture. For a cabinet only 65 inches high and a trim 120 pound chassis, the designers have produced an image measuring 35 x 35 even though it is only 24 inches at the narrowest circumference.

Of course even the finest of instruments may go haywire periodically, requiring the repairs shown in the pictures.

Incidentally, the name of our beauty is Joanne Holler. Joanne is a speech correction major at GWU. She has won a number of local beauty contests in the Washington area, as well as placing just a whoop and a Holler from first in the recent Miss Universe Contest.

Photos by Tom Beale

SLIPSTICK



THE ENGINEER

Who is the man that designs our pumps with judgment skill and care?
Who is the man that builds them then keeps them in repair?
Who has to shut them down because the valve seats disappear?
The bearing-wearing, gearing-tearing Mechanical Engineer.

Who makes his juice for half a cent then wants to charge a dime?
Who, when we've signed the contract can't deliver half the time?
Who thinks a loss of twenty-six per cent is nothing queer?
The volt-inducing, load-reducing Electrical Engineer.

Who is it takes a transit out to find a sewer to tap?
Who then with care extreme locates the junction on the map?
Who is it that digs it up and finds it no where near?
The mud-bespattered, torn and tattered Civil Engineer.

Who is it makes all A's and B's while others fret and fume?
Who is it can play cards all day in some secluded room? ?
Who is that man that drinks and smokes and never exams does fear?
The beer consuming, girl pursuing, Business Administrationeer.

< • >

Overheard in E.E. LAB

Tony: Roy grab this lead. Feel anything?

Roy: No.

Then watch the other one, it's carrying 22,000 volts.

< • >

Wisdom—Knowing what to do.
Skill—knowing how to do it.
Virtue—not doing it.

A divinity student named Tweedle
Refused to accept his degree
He didn't mind the Tweedle
But he hated to be Tweedle, D.D.

< • >

Did you hear about the cannibal's son?

He liked his girls best when they were stewed.

< • >

M.E.: Alas, drink broke up my home.

E.E.: What's the matter couldn't you lay off the stuff?

M.E.: No, my still exploded.

< • >

And then there was the Business Administration student who let his M.E. roommate fix him up for a blind date with Allis-Chalmers.

< • >

Alimony: A system by which two people make a mistake and one continues to pay for it.

< • >

Chemistry Professor: Tell us what you know about nitrates.

Dozing Engineer: I don't know much about them except that they're cheaper than day rates.

< • >

Host: This bronze urn contains my dear grandmother's ashes.

Guest: Oh, did the poor soul pass away.

Host: No, just too lazy to hunt up an ash tray.

< • >

Wife: I thought you were going to the lodge meeting tonight?

Howard: It was postponed. The wife of the Grand Exalted Invincible Supreme Potentate wouldn't let him out tonight.

WHAT THEY MEAN WHEN THEY SAY . . .

See me after class—*It has slipped my mind.*

Pop Quiz—*I forgot my lecture notes.*

I will derive—*formula has slipped my mind.*

Closed book quiz—*Memorize everything including the footnotes.*

Open book quiz—*Oil your slide rules and wind your watch.*

Honor system — *alternate seats.*

Do odd numbered problems — *the even numbered problems will be on test.*

Briefly explain—*not less than 1000 words.*

< • >

Two engineering students were discussing the careless way their trunks and suitcases had been handled by the railroad companies.

"I had a very cute idea for preventing it once." ventured one. "I labeled each of my bags "With Care —Breakable — China."

"Did that have any effect." said the other.

"I don't know yet," was the reply, "They shipped the whole lot off to Shanghai."

< • >

The Mechanisms classes are still talking about the Electrical Engineer who thought that a pantograph was an underwear pattern.

1,000 styles—750 stores—yet photography gives headquarters inventory figures overnight

Thom McAn ends ten-day hand-copying jobs with Kodak's Verifax Copier—now gets complicated sales, size and style data off in a day.

Before, when Thom McAn's merchandise manager or stylist needed word on sales or style trends in certain stores, it took as much as ten days to hand-copy the records.

But today, when headquarters located in New York requests information on any shoe style or store, the New England merchandising center gets the latest facts and figures away in that night's mail. And styling, buying and distributing functions get 24-hour—instead of ten-day—service on vital stock allotment statistics.

This is because the facts, kept on files of removable panels and cards, can be slipped into a Kodak Verifax Copier and copied, photographically accurate, in a minute.

Photocopying is just one of hundreds of ways photography works today for all kinds of businesses, large and small. It helps with product design, takes kinks out of production, increases sales, improves customer and personnel relations.

Thom McAn calls the Verifax Copier "the kingpin of the allotment control system." It copies a store's style allotment records and width breakdowns and in less than 60 seconds has a dry print ready for the mails.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

CAREERS WITH KODAK

With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design and production. If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

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